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Technical Mine Master Plan for PPC s LCPA and LCM

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Prepared by

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The Masterplan Team

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Technical Mine Master Plan for PPC s LCPA and LCM

Rheinbraun Engineering, Cologne has been entrusted, to prepare a Tecnical Mine Master Plan (TMMP) for PPC s Lignite Centre Ptolemais - Amyntaion (LCPA), and to review the existing Masterplan for PPC s Lignite Centre Megalopolis (LCM). This work is to be carried out by a group of PPC- and RE-engineers, the Masterplan Team. Both plans shall deal with the period of time until 2020. The locations of the deposits, mines and power stations involved in this work are shown in *[ATT1 - 1 / 03]* [1]

Scope of Work:

The main subjects in the scope of work are:

- Phase 1: Data Collection and Evaluation,
- Phase 2: Alternative Solutions,
- Phase 3: Mine Operations,
- Phase 4: Lignite Quality, Ash Transportation Environment and
- Phase 5: Cost Calculation.

Executive Summary:

In the phases 1 - 5 the following results have been achieved:

Phase 1: Data Collection and Evaluation *[SCT 1]* [2]

According to the contractual scope of work

- the lignite demand
- the essential deposit properties (lignite quantity, quality, mining ratio),
- the capacity of the equipment,
- personnel- and
- cost data

are to be collected.

The Lignite Demand:

The future lignite demand results to the evolution of the total electricity demand in the so called Mainland Grid of Greece (Only a part of the Greek islands has been connected to the Mainland Grid up to now) and to the future evolution of the load duration curve for this grid (The lignite fired power station capacity needs to be operated on a high level of utilisation due to techno-economical reasons).

[1] See Section 7,4 - N° 1
[2] See Section 7,4 - N° 2

The total demand of electric energy was assumed to increase by increasing yearly increments in the past. The graphical representation for the total demand of electricity appears however to have passed already a turning point. We are to assume a still continuously increasing demand. The yearly increment is, however, decreasing again already.

The utilisation of the lignite fired base load capacity in the Mainland Grid of Greece is too low at present. Among other reasons, which have not been investigated by the Masterplan Team, the high installed base load capacity in context with the shape of the load duration curve might be one reason for this low utilisation

Lignite Reserves, Mining Ratio:

Due to various reasons described below the determination of the remaining lignite reserves has been an essential but complicated item of our scope of work:

Basically a representation of the mine geometry is to is to be set up in the form of coordinates (Mine modelling). The same applies to the waste and lignite layers and to the distribution of the quality parameters for those layers, which may become a part of a lignite block (Deposit modelling).

Both Fields of activity are to be commented as follows:

- Mine modelling: The possibility to apply mine models with inclined slopes has been improved and extended. Due to mine modelling procedures applied up to now for bench wise masscalculations, major deviations beween their results and masscalculations without beches have been observed. an improved bench modelling procedure has been introduced.
- Deposit modelling: The results of masscalculations for PPC s multi layer deposits depend within wide limits
  - on the algorithms for the determination of lignite and waste blocks (Composites including several lignite layers and the intercalations between them),
  - on the algorithms for the calculation of the average lignite quality,
  - on the accuracy of the quality input for lignite layers and for all waste layers, which might become part of a lignite block and
  - on the power stations specification for the calorific value. A low calorific value is related to increasing reserves and vice versa.

  The Masterplan Team changed algorithms for the definition of blocks and for the calculation of the average quality parameters. Previous assumptions for the input of quality data have been revviewed as well. These changes resulted in remaining reserves and quality parameters different from the figures assumed up to now.

These new figures triggered an intensive, ongoing discussion with our counterparts in the lignite centres. A certain approximation of the different points of view has been achieved in the meantime. A final agreement is, however, still pending.

Up to now the strata of the deposit are not correlated. Hence the geo-hydrological information as a basis for geotechnical investigations and finally for the masscalculations is not sufficient.

The Capacity of the Equipment:

The utilisation of the Main Mine Equipment in PPC s mines is rather low. The main reasons and the corresponding remedy measures can be described as follows.

The number and capacity the receivers (Spreaders and lignite handling systems) installed in PPC s mine systems, does not correspond in any case to the number and capacity of the donors(Excavators).

There are however possibilities, to adjust the receiver capacity as required by technical measures e. g. by adjustments of the belt velocity on the spreaders. Belt velocities up to

7,5 [m/sec]

are the „state of the art" at present. In special cases a belt velocity up to

15 [m/sec]

has already been applied successfully. We do not regard the lack of theoretical spreader capacity in PPC s mines as a serious problem.

The theoretical capacity of the belt conveyor system does not correspond in any case to the theoretical capacity of the excavators. The conveyor system is oversized in some cases. In other cases it is clearly undersized.

Technical remedy measures have been proposed by the Thalis Symphonia project. there is no need for additional investigations in context with the TMMP.

Another important operational constraint is the lack of drive power of the belt conveyor system (especially the dump conveyor sections).

In PPC s mines the difference between the actual load factor and the standard figure for this parameter is bigger than the difference between the actual time factor and the corresponding standard figure. This is unusual. We have frequently observed abroad, that an acceptable load factor is achieved much easier than an acceptable time factor. The reasons, why this does not hold true in PPC s mines have been described above.

The aforementioned lack of drivepower results to the lack of mid and short term planning capacity in the mines. A standard mid term planning procedure is the yearly review of the bench wise mine planning for a period of time of 5 -10 years. The length and lift for each conveyor section is then used as the base for a check-up of the drive power requirements and corresponding remedy measures resulting in an increasing load factor.

At the same time the schedule of operational events, resulting to the mid term planning activities described above, allows for

- the co-ordination of operational events and maintenance activities
- smaller time requirements for both of them (Only such activities can be planned in an appropriate way, which are known sufficiently early prior to start up).

The influence of mining lignite and waste selectively and the necessity to remove hard material are not the most essential reasons for the deviation of the equipment utilisation achieved in PPC s mines at present. Not the thin individual layers are to be mined selectively, but the so called blocks (lignite / waste composites), which are much thicker. The present procedures of hard rock removal are not regarded as the best possible approach. Improved procedures of hard rock removal are expected, to result in lesser reductions of the equipment utilisation.

Based on these considerations we expect the utilisation of the Main Mine Equipment to increase considerably, after the remedy measures described in this report have been executed.

The Personnel:

Personnel requirements and the training measures for PPC staff have been determined in the Thalis Symphonia project. Within the TMMP no additional activities in this field have been carried out.

Cost Data:

In order to allow for a comparison of the cost calculations by the Masterplan Team, cost figures generated by PPC have been collected.

Phase 2: Mine Operations *[SCT 2]* :

The concepts of development for the LCPA and for the LCM have been designed or reviewed and adjusted.

LCPA:

We regard the following facts as essential in context with the design of the Technical Mine Master Plan for the LCPA:

- If the capacity of the lignite fired power stations is not reduced in time, the lignite reserves for the major part of the lignite fired power station capacity expire during the time period until 2020 or shortly after that point of time.
- The mining ratio increases as a function of the time. In this case an increasing equipment capacity is to be employed.

- Due to the restricted lignite reserves the employment of additional equipment during the last part of the mine life, when the mining ratio is expected to increase, is not regarded as economical.
- Due to the multitude of strata, forming PPC s lignite deposits, the reserves depend much more on the calorific value, to be achieved, than normally observed.

According to these considerations this is our basic concept for the development of the Technical Mine Master Plan for the LCPA:

By combining a decreasing lignite demand, which results to a decreasing capacity of the lignite fired power stations in the LCPA and the LCM, with the inevitably increasing mining ratio, it is our intention to keep the requirements of equipment capacity low. Investments for additional mine equipment are to be avoided. We regard this approach as favourable, as it corresponds to the economical necessity, to save expenses where possible, in order to keep the most important source of electric energy in Greece competitive compared to other sources of electric base load energy (e.g. imported black coal).

In an early phase of our work a decision has been made, to evaluate PPC s lignite deposits based on the assumption, that only lignite is to be supplied to the power stations, in order to assess the remaining reserves conservatively.

In the case of the Sector 6 & West Field South mine and in the case of the West Field North a low grade deposit is to supply a power station with, which calls for a high calorific value. In these cases we suggest, to investigate the feasibility of supplying „other fuels" (e.g. dry lignite) to the consumers of the lignite released by these mines. As a consequence we expect considerably increasing reserves of thermal energy at a decreasing mining ratio in the Sector 6 & West Field South mine and in the West Field North.

At present the peak lignite production is expected for the year 2000 (52,4 Mt/a). The corresponding maximum total excavation is will be necessary in the year 2015 (278,8 Mm^3/a). Under the aforementioned preconditions no additional main mine equipment is required. Local lacks of mine capacity are, however, to be removed by the exchange of equipment (E. g. from Amyntaion to the West Field North and back, from the South Field to the Sector 6 and back).

On the other hand important mid term planning tasks have to be carried out based on the long-term planning concept by the internal units in each mine (Yearly review and extension of the mid term, bench wise planning for each mine).

LCM:

In the LCM the necessity of conceptual adjustments results to different reasons, related to the methods of drillhole evaluation applied in the past and to the concept of development of the Horemi and Marathousa mines.

The methods of drillhole evaluation applied in the past are described in the study of Prof. Goergen which is to be reviewed by the Masterplan Team. Two different sets of evaluation criteria are applied. For the majority of the drillholes the lignite and waste layers in the drilling logs have been accumulated, without taking into account a minimum thickness of lignite and waste layers, which can be excavated selectively, mining losses and dilutions or any quality limits.

This method of evaluation results in a quality trend in the deposit. Generally spoken the calorific value of the lignite is high in the Horemi mine, and it tends to lower figures in the northern part of the deposit (Kyparissia Mine).

As a consequence of this trend it is strongly recommended by Prof. Goergen, to blend the lignite from the three LCM mines, which are then operated not as economically as possible in parallel.

As we see it, the basic assumption of a trend of the calorific value in the LCM deposit is, however, a result of the inappropriate evaluation of the deposit. Under the circumstances described above, it reflects the fact, that the deposit is less splitted in the south than in the north. In a multi seam deposit as in the LCM the average ash content in less splitted areas is expected to be lower than in more splitted areas. Based on recently received drillhole information the water content in Kyparissia is, however, clearly higher than in the south.

These differences referring to the average water- and ash-content of the layers, specified as lignite in the drilling log, must, however, not necessarily result in a corresponding trend of the calorific value. In a multi layer deposit the calorific value can be adjusted according to the specifications of the power station. Corresponding changes of the reserves are the consequence.

The blending necessities may have been over emphasised in the past. We see the possibility to reduce the number of LCM mines and to reduce the average production costs at the same time(scale effects).

In the present concept for the development of the Horemi mine and the Marathousa mine a part of the dam between both mines remains unexploited as a support for the inpit dump of Horemi. Because the four benches of the Marathousa mine are to be exploited by only two excavators, the inpit dump of the Marathousa mine will become very small (Slope stability problems: The permanent perimeter slope of Marathousa remains almost without support by an inpit dump). There is, however, a lack of dumping volume, as the expit dump in the former Thoknia mine is not sufficient for the Marathousa waste and the ash from the four Megalopolis units.

Due to the fact that the development of the excavation benches 4-6 of the Horemi mine has been postponed, as the required belt conveyor material for the development was not available, the minimum volume of the external dump is almost consumed at a point of time, when three excavation benches and all three inpit dump benches are still to be developed.

The Masterplan Team suggests to adjust the concept of development of the LCM mines as follows in order to remove ore at least reduce the aforementioned problems:

- The dam between the Horemi and Marathousa mine is to be exploited completely.
- After having exploited Marathousa, the final void is to be filled up completely. It is suggested to relocate the ash dump to the Marathousa final void for this purpose. Horemi waste can be added as required. This measure reduces the requirements of dumping volume on the Thoknia dump and removes the geotechnical problems in the Marathousa final void.
- We suggest to steer the progress of the LCM mines in the next period of time by setting the priority for the operation of the excavation activities as follows:
  1. Horemi: benches 4 - 6
  2. Marathousa and Kyparissia
  3. Horemi: benches 1 - 3
- As soon as the development of the inpit dump in Horemi has been initiated, the benches of the inpit dump must be operated at a higher priority than the benches of the expit dump.

This strategy will be expediting the transition from the expit dump to the inpit dump in Horemi, and the demand of additional expit dumping volume, we are expecting according to the above described status of the Horemi mine will be reduced correspondingly.

At the same time an earlier completion of the exploitation of the Marathousa and Kyparissia is approached by this strategy (cost reductions).

The unusual status of development of the Horemi mine (Shortly before having consumed the expit dumping volume completely there are still three excavation benches and three benches of the inpit dump to be developed) calls for a bench wise investigation of at least the next five to ten years.

In the Marathousa mine a mine depth, which calls for the employment of four excavators, is exploited by two excavators. The steering of this mine calls for a bench wise development as well. A smooth development of the missing two benches cannot be achieved without this measure.

Phase 3: Mine Operations *[SCT 3]*:

The major fraction of the scope of work for the section 3 is at the same time part of the section 2. Insofar section 3 contains references to the section 2

Phase 4: Lignite Quality, Ash Transporttion, Environment *[SCT 4]*:

In this section special subjects are to be investigated. These subjects are:

- The use of the stockpiles for the safety of the lignite supply at an acceptable quality,
- the transportation and deposition of ash,
- the interlinking lignite handling systems,
- earth removal projects,
- personnel requirements, training of personnel.
- environmental study for the LCPA

Phase 5: Cost Calculation *[SCT 5]*:

The last item of the scope of work of for the TMMP are considerations referring to the costs.

The most important result is here, that the mine areas in the LCPA and in the LCM, which have been included into our planning work (The Proastio Field, the East Field and the Sarigiol Section of the South Field have excluded for economical reasons) are economically exploitable.

The energy price for lignite is below the energy price for e. g imported black coal, which is a strong competitor lignite in other countries.

This is, however, no reason, to finish PPC s efforts, to achieve further cost reductions. EC regulations, which are to be expected in the future, will put additional costs especially on the electric energy produced on lignite basis. Another intention of the European community is, to introduce mor economical competition into the European energy market.

Final Remarks

The concept of development for PPC lignite mines in the LCPA and in the LCM don't represent a basis for the lignite mining activities in these areas, which remains applicable for an indefinite period of time.

The following reasons support this statement:

Our determination of the lignite demand is based on a numerical analysis of actual generation figures. The lignite demand figures can only be kept reliable by regular reviews including the latest actual figures. As soon as considerable deviations from our present prognosis occur, a review of our work is to be carried out.

In context with the remaining lignite reserves in the LCPA and in the LCM the earlier decommissioning of the older lignite fired units in the LCPA, beginning with the first unit of the Liptol power station in the year 2003, has been proposed. This necessity is to be discussed with PPC s Direction of Programming and Strategic Planning. One potential consequence is the erection of additional base load capacity. On the other hand the missing decommissioned capacity could result to a higher level of utilisation for the remaining base load capacity. At least until 2003 the earlier decommissioning of the lignite fired units will not influence the operating ase load capacity. For later periods of time the necessity, to review our work is expected.

Up to now the geological, hydrological and geotechnical investigations as the basis of for masscalculations have not achieved an appropriate level of accuracy. In this context the geotechnical investigations in the area of the safety pillars of the Kardia, Ptolemais and Liptol power stations and of the western perimeter slope of the two parts of the West Field are mentioned again, as these activities may influence the exploitable reserves considerably. The same applies to the up to now unknown quality parameters of the strata without analysis, which have been introduced as waste with high ash content. An unknown fraction of these strata is for sure exploitable lignite. After having correlated the strata in PPC s deposits these conservative assumptions can be replaced by the quality parameters of the same strata in other drillholes in the neighbourhood. Changing remaining reserves, related to this effect, can again be a reason for a review of our work.

There is, however not, only the necessity, to review the TMMP after a certain period of time (about five years). The TMMP is the basis for the mid term and short term planning activities in the internal planning units in the mines, as proposed in the Thalis Symphonia Project. Without the appropriate mid- and short term planning the guidelines of the TMMP cannot become effective.

Conclusions and recommendations, referring to matters as described above, have been comprised in the *[SCT 6]* of this report.

In *[SCT 7]* references have been collected.

1 Phase 1: Data Collection and Evaluation

The first phase of our work was the collection and evaluation of the basic data for the subsequent planning work.

This activity includes the fuel demand of the consumers of PPC lignite (Quantity and quality). The fuel demand and the mining ratio result in the total excavation requirements, which are to be fulfilled by the mine equipment.

Hence these three parameters are the most important input data for the preparation of the TMMP.

According to the scope of work and having in mind the statement above, the following subjects are to be dealt with in the section "Data Collection and Evaluation":

- The Lignite demand,
- The remaining reserves: Waste and lignite quantities, lignite quality, mining ratio,
- the mine equipment,
- the personnel and
- cost data.

1.1 The Fuel Demand of the Lignite Fired Power Stations

The lignite demand, to be supplied by PPC s lignite mines in the LCPA and in the LCM depends on the future operation schedules of the consumers of PPC lignite

The Consumers of PPC Lignite:

The biggest fraction of PPC s Lignite production is consumed for the supply of electric energy to the Mainland Grid of Greece.

A minor fraction of the production has been used for the production of briquettes in PPC s Liptol power station and briquetting plant. The demand of lignite for the production of briquettes is small.

As PPC has erected district heating systems for the cities of Kozani and Ptolemais, the demand of briquettes may be reduced in future. The district heating systems for Kozani and Ptolemais will not result to an increased lignite demand but to a slightly reduced production of electric energy.

A fertiliser plant (AEBAL), which has been consuming small quantities of lignite in the past, is not operating any more.

In order to determine the future Lignite Demand, we have to analyse the production of electric energy in the Mainland Grid of Greece.

<u>The Mainland Grid of Greece:</u>

Geographically the Mainland Grid of Greece comprises the Greek Mainland and a fraction of the Greek islands, which have already been connected to the mainland by cable links. The integration of the islands into the Mainland Grid of Greece will continue in the future. In this context the plan, to connect the island of Crete to the Mainland Grid of Greece is to be mentioned. At present the yearly consumption of the islands not yet integrated into the Mainland Grid of Greece is about 7,1 % of the consumption in the Mainland Grid of Greece *[ATT 2- 1]*. The ongoing integration of the islands is not expected to influence the trend of consumption in the Mainland Grid considerably. In the last years the electrification of Greece has been completed. The ongoing electrification of Greece has been an important reason for the quickly increasing electricity demand in the past. As this reason does no more apply in the future, one should expect the electricity demand to increase at a decreasing yearly rate in the future.

External Links of the Mainland Grid of Greece

The Mainland Grid of Greece is interconnected to the networks of the neighbouring countries. Through its 400 kV connection with ex Yugoslavia it is in synchronous and parallel operation with the interconnected systems of Western Europe - UCPTE . An additional cable link to Italy is scheduled to commence operation at the end of 1997. The following connections are existing at present;

Country	:	Voltage [kV]	Power [kVA]
Albania	:	150	138
Albania	:	400	1400
ex Yugoslavia	:	150	138
ex Yugoslavia	:	400	1400
Bulgaria	:	400	1400

Net Generation, Power Station Capacity, Utilisation of the Power Station Capacity:

The evolution of the net generation of electric energy in the Mainland Grid of Greece, on the islands and the total net generation in Greece is shown in attachment *[ATT 2-1]*.

The lignite fired capacity is to be operated as base load capacity. As a standard figure for base load units a utilisation of about 0,750 ± 0,050 [--] is normally assumed.

In attachment *[ATT 2- 2 / 6]* the evolution of PPC s power station capacity in the past and as far as it is already known at present until 2020 is presented.

The fuel demand depends on the capacity and utilisation, on the specific requirements of thermal energy for the generation of electricity of the power station units under consideration. Additionally the specification of the fuel quality for these units and the quality of the fuel supply must correspond to each other.

According to these considerations we are to investigate the following subjects in context with the lignite demand of the lignite fired base load power stations:

- The capacity and the utilisation of the base load units,
- the specific requirements of thermal energy of the base load units,
- the specification of the fuel for the base load units,
- the quality parameters of the lignite and
- conclusions referring to the lignite demand.

The Masterplan Team spent a considerable fraction of the contractual time budget for the determination of the future lignite demand. The results of this part of our work presented below are, however a justification for the decision to do so. The lignite demand is perhaps the most important basic input for the design of the long term concept of development of PPC s mines.

1.1.1 The Capacity and the Utilisation of the Base load Units

The capacity and utilisation of the lignite fired base load units in the Mainland Grid of Greece is a consequence of the load duration curves for the total power station capacity and for the base load capacity, which are to be adjusted to each other.

In the attachment *[ATT 2- 6]* an example for the load duration curve for the total capacity and for the lignite fired capacity in the Mainland Grid of Greece is shown. On the X - axis the accumulated yearly operation hours are shown, during which the corresponding capacity on the Y - axis has been required. In order to allow for simple and sufficiently accurate calculations the actual load duration curves can be replaced by simplified curves, where a rotational symmetry with the centre of symmetry at 4 380 operation hours (in the middle of the calendar year) is assumed. A simplified load duration curve as such is shown in attachment *[ATT 2- 7]*.

The formula symbols in this attachments are defined in attachment *[ATT 2 - 8 / 9]*. The Load duration diagram shows the relations between the operation of the total power station capacity and the base load capacity. The net generation of the total capacity NG_t divided by the calendar time C results to the average or mean load of the total system P_{avt}. Due to the aforementioned assumption (Rotational symmetry) The maximum load P_{mat} and the minimum load P_{mit} are found at zero calendar hours or 8760 calendar hours at equal vertical load distances above or below the average load..

We learnt, that the total minimum load P_{mit} cannot be assigned completely to the lignite fired base load units. Due to technical reasons the oil fired medium load units cannot reduce their capacity down to zero during the valley hours. There is a difference to be maintained between the total minimum load P_{mit} and the minimum load of the base load units P_{mib}.

The assignment of a fraction of the minimum load P_{mit} to the medium load capacity in the Mainland grid of Greece is not the normal case. Normally the base load units supply the total demand of electricity during the valley hours of each day, when only slow load variations occur. During this period of time the restricted capability of the base load units, to adjust their capacity to the required load is sufficient. Hence the minimum load of the base load units P_{mib} should be expected to be slightly higher than the total minimum load P_{mit}.

The load duration curve for the base load units should allow, to achieve a utilisation factor u_b in the order of

$$0{,}700 < u_b < 0{,}800.$$

The utilisation u_b is defined as

$$u_b = P_{avb} / P_{inb}$$

For the frequency regulation in the grid especially during the daily valley hours, when the base load units are expected to supply the total energy requirements, a reserve capacity must be available. The reserve factor r_b is defined as

$$r_b = P_{inb} / P_{mab}$$

The utilisation and reserve factors result to the load factor l_b, which is defined as

$$l_b = u_b \times r_b = (P_{avb} / P_{inb}) \times (P_{inb} / P_{mab}) = P_{avb} / P_{mab}.$$

If the reserve factor r_b is too high, and if the base load power stations do not achieve an a sufficient load factor l_b a low utilisation factor is the consequence, which is not economical. The „profile" of the load duration curve for the base load units below the load duration curve of the total power station capacity must be sufficiently flat.

According to these general considerations the following subjects are to be described in context with the capacity and utilisation of the lignite fired base load capacity in the Mainland Grid of Greece:

- All units, net generation = f (time)
- all units, maximum load = f = (average load)
- all units, Installed capacity, capacity reserves, utilisation
- lignite fired units, base load difference
- lignite fired units, maximum load = f (minimum load)
- lignite fired units, Installed capacity, capacity reserves, utilisation
- lignite fired units, period of operation & lignite reserves

From our point of view these investigations do not result in figures, referring to the capacity and utilisation of the lignite fired base load capacity, which are a sufficiently reliable basis for the preparation of the TMMP. The future utilisation of these power stations have been underestimated. the capacity requirements have been overestimated. Accordingly the already reduced remaining capacity of the lignite fired units in the LCPA and in the LCM is expected to operate on a higher level of utilisation in future than assumed up to now.

1.1.1.1 All Units, Net Generation = f (Time)

During the first period of our data collection activities only short term scenaria for have been available in this context. These scenaria covered normally a period of time of ten years, which was not sufficient for our work. A first scenario for the period of time until 2020 has been presented in July 1994.

At this point of time the Masterplan Team had already carried out major fractions of the work required in this field. Hence we are going to compare to compare the results of both investigations to each other in the following sections of the report.

Our prognosis results to a numerical analysis of the actual net generation figures, which have been collected since 1961 by PPC. These figures are presented in [ATT 2- 1]. In order to choose a conservative approach, we used the total net generation including the balance of purchase and exchange and the net generation by the autoproducers as the basis of our investigation.

In principle we expect an evolution of the net generation as a function of the time as shown in attachment *[ATT 3 -1 / 2]*. The net generation cannot continue to increase forever. After a first phase with increasing yearly increments, the function passes a turning point, and the yearly increments start to decrease again. This might apply for the Mainland Grid of Greece already, as the electrification of the country has been completed recently.

For the analysis of the actual figures we used the Microsoft Excel function "Trend". In order to determine, whether the function, described above has already passed its turning point or not, we analysed a moving period of 25 years starting with the years 1961 until 1985 and ending with the Period of time between 1970 until 1994. The regression analysis with the Microsoft Excel function „Trend" results to the function

$$NGt = m \times t^{e} + b = 1{,}281 \times t^{0{,}9439} + b \text{ [GWh]}$$

for this time period. In this formula „t" is the number of years since start up of the moving period of time in years. As soon as the exponent „e" in this function becomes smaller than 1 we can assume that the function has passed its turning point, and decreasing yearly increments are to be expected in future

The results of this analysis are shown in the attachments *[ATT 3 - 3 / 13]*. As a matter of fact the exponent „e" decreased from

e= 1,17

over the period 1961 until 1985 to

e= 0,94

for the period 1970 until 1994. This indicates, that in the future decreasing yearly increments are to be expected, because the net generation as a function of the time has already passes its turning point.

In the attachment *[ATT 3-14]* The accuracy of this analysis has been assessed. The available figures allow for two approaches to this matter.

The net generation figure for the year 2020 has been assessed based on ten different sets of actual figures for 25 years each in a different time distance from the year 2020. The biggest time distance (actual figures 1961 - 1985) results in a net generation for 2020 of

70 250 [Gwh/a].

The analysis of the next three sets of actual data results in a strong reduction of the net generation figure for the year 2020.

The remaining data sets result in net generation figures, which undulate slightly within narrow limits a little above or below

60 000 [Gwh/a].

One can expect this effect, if the function

net generation = f (time)

is passing its turning point during the period of time under investigation. The small changes of the net generation for 2020, which are found by the analysis of the last seven data sets, might indicate, that these data sets are already located beyond the turning point of this function.

A second approach is the comparison of old prognosis figures with the corresponding actual figures. The deviations between these data sets are an indicator for the accuracy to be expected in future.

The average deviation between prognosis figures determined one year before the actual figure is

2,14 %.

It is important, to know the net generation in five years from the present point of time, because the erection of a power station, takes about a period of time of five years. The average deviation of our prognosis from a distance of time of five years is

1,63 %..

Another essential figure is the accuracy of a prognosis for a time distance of about ten years. Ten years prior to commissioning the planning work for a power station should be started. The accuracy of our prognosis for this time distance cannot be judged up to now, because the available data base is not sufficient. As a rough estimation the first prognosis figure for a time distance of nine years can, however be mentioned. The deviation from the corresponding actual figure is

3,94 %

in this case.

In the attachment *[ATT 4 - 2 & 5]* the actual net generation figures, our prognosis (NGt'), an old ten years prognosis by PPC (NGt") and PPC s prognosis until 2020 (NGt"') can be compared to each other. PPC s prognosis for the period of time until 2020 and the result of our own investigations are rather close to each other. There appears, however to be no relation between the old 10 years prognosis and the actual figures. If the planning and the subsequent erection of power station capacity was scheduled according to a prognosis as such, an excess of power station capacity and a low utilisation of the power stations was the inevitable consequence.

1.1.1.2 All Units, Maximum Load = f (Average Load)

The net generation figures and the calendar time are the necessary input for the calculation of the average load of the total capacity P_{avt}. The design of the schedule for the expansion of the power station capacity calls, however, for additional input information, because between the maximum load and the installed capacity an appropriate reserve capacity is to be kept available.

Based on the actual figures for the years 1980 until 1994 the evolution of the total maximum load as a function of the total average load has been analysed with the Microsoft Excel Function "Trend". We assumed, that a straight line describes this trend. The calculation resulted to the function:

$$P_{mat}''' = m \times P_{avt} = 1{,}449 \times P_{avt} \text{ [MW]}$$

In the attachment *[ATT 4 -1, 3 & 7]* the actual total maximum load figures P_{mat}, the result of our trend analysis P_{mat}''' and a prognosis by PPC P_{mat}'' are compared. Both graphs are close together.

1.1.1.3 All Units, Evolution of the Load Duration Diagram

After having designed the load duration diagram for the base load units *[SCT 1.1.6]*, we are then in the position to determine the load duration diagram for the total capacity in the Mainland Grid of Greece.

In this context the following three utilisation parameters to be taken into account:

- The load factor l_t : $l_t = P_{avt} / P_{mat}$
- The utilisation u_t : $u_t = P_{avt} / P_{int}$
- The capacity reserve r_t : $r_t = l_t / u_t = P_{int} / P_{mat}$

(See attachments [ATT 2 - 7], [ATT 4 - 1].

A standard figure for the load factor of the total capacity as observed in other grids abroad is

$0,500 < L_t < 0,600$

The actual figures achieved in the Mainland Grid of Greece are higher.

$0,659 < l_t < 0,727$ *[ATT 4 - 1].*

The load duration curve of the Mainland Grid of Greece has a favourably lower profile compared to the standard case.

As a rough guideline for the reserve factor „r_t" we found

$1,200 < r_t < 1,250$

The actual reserve factors in the Mainland Grid of Greece are higher.

$1,310 < r_t < 1,648$ *[ATT 4 - 1].*

Combining the upper limit of the standard load factor with the lower limit of the reserve factor and vice versa, standard limits for the utilisation factor „u_t" can be defined.

$0,400 < u_t < 0,500$

The actual utilisation factors are in the order of

$0,419 < u_t < 0,513$ *[ATT 4 - 1].*

Due to the high reserve factors „r_t" the high load factors „l_t" results in only slightly higher utilisation factors „u_t".

For our prognosis of the load duration curve for the total capacity the following procedure has been applied *[ATT 4 - 3]*:

- We adopted our prognosis for the total net generation NGt''' *[SCT1.1.1]*.
- The average load for all units together P_{avt}''' was calculated by dividing the net generation NGt''' through the calendar time.
- The load factor l_t''' was set at

  $l_t''' = 0,690$

  This corresponds to the result of our regression analysis *[SCT1.1.2]*.
- The maximum load P_{mat}''' is then the product of the average load P_{avt}''' and the load factor l_t'''.

  $P_{mat}''' = P_{avt}''' \times l_t'''$
- The installed capacity P_{int}''' is set, in order to achieve a reserve factor r_t''' in the order of

  $r_t''' = 1,300.$

  As soon as the reserve factor became lower than this figure the next increment of the installed capacity has been introduced (See attachment *[ATT 2 - 10].*
- The utilisation factor has then been calculated as the quotient

  $u_t''' = P_{avt}''' / P_{mat}'''$

- Applying the concept of the simplified load duration curve it has been assumed, that the difference between the maximum load $P_{mat'''}$ and the average load $P_{avt'''}$ is equal to the difference between the average load $P_{avt'''}$ and the minimum load $P_{mit'''}$.

The installed capacity in PPC s scenario *[ATT 4 - 2]* has been added by the Masterplan Team according to *[ATT 2 - 1]*. The final installed capacity for the year 2020 is not comparable to the figure in our scenario *[ATT 4 - 3]*, because the reserve factor is lower in PPC s scenario. If a reserve factor of

$r_{t'} = 1{,}300$

is applied for the PPC scenario as in the TMMP scenario, the total installed capacity $P_{int'''}$ (TMMP) is lower than the total installed capacity $P_{int'}$.

$P_{int'} - P_{int'''} = 13.208 - 12.849 = 359$ [MW]

The investments for additional power station capacity are correspondingly lower.

The minimum load $P_{mit'''}$ (TMMP) is generally lower than the minimum load $P_{mit'}$ (PPC). This is an advantage, as the minimum load for the base load units P_{mib} will be also higher in this case, and the net generation of the base load units will increase correspondingly.

1.1.1.4 Base Load Units, Minimum Load Difference

The lignite fired power station units in the Mainland Grid of Greece are the only base load units in the mainland grid of Greece at present. In order to achieve an economical operation the utilisation u_b of these units should be

$0{,}700 < u_b < 0{,}800$.

An additional objective is, to assign a high percentage of the total net generation to the lignite fired base load units.

The achievement of both targets is supported, if the lignite fired units are allowed, to provide the total minimum capacity requirements, shown in the load duration diagram. This did not apply in the past. A fraction of the minimum load requirements in the load duration curve has been assigned to the oil fired power station capacity, which is not the usual situation. Normally medium load capacity is switched off completely and started again more than once per day if necessary.

In the attachment *[ATT 4 - 8]* the evolution of the difference between the minimum load requirements for all power station units P_{mit} and for the lignite fired base load units P_{mib} in the Mainland Grid of Greece is shown.

This difference has become smaller and smaller since 1984. It was zero or almost zero in the year 1994 (In this context it must be mentioned, that both minimum load figures have been determined under the assumption, that the load duration curve can be simplified, as described before).

From our point of view this is a favourable evolution, which is, however, contradictory to the information we have received before.

1.1.1.5 Base Load Units, Maximum Load = f (Minimum Load)

The load variation for the base load units in the Mainland Grid of Greece is an essential input for the preparation of the Technical Mine Master Plan for several reasons.

Firstly the total requirements of base load capacity are to be adjusted to the maximum load taking also into account the necessary capacity reserve. The base load capacity, installed based on these considerations is related to the achievable utilisation u_b, which must be known sufficiently accurate for the assessment of the lignite demand.

Secondly the reserves of mine capacity, the capacity of the lignite handling systems and the stockpile volumes in these systems must correspond to the load variations for the base load units.

In context with this matter we investigated

- the load variations for the total base load capacity and
- the load variations for the individual power stations.

From our point of view the variation of the power station load will decrease, as soon as the utilisation of the power station capacity increases. taking into account the capacity reserves for the primary regulation of the frequency in the Mainland Grid of Greece, only minor changes of the load are possible, if the level of utilisation is high.

1.1.1.5.1 Total Base Load Capacity

For our analysis of the load duration curve for the total base load capacity only little actual data from 1984 until 1994 available *[ATT 4 - 4]*.

These data have been analysed with the Microsoft Excel function „Trend". A linear function, which crosses the origin of the system of co-ordinates, has been assumed for this purpose. This analysis results in the function

$$P_{mab} = m \times P_{mib} = 2{,}210 \times P_{mib} \text{ [MW]}$$

The average load P_{avb} is then

$$P_{avb} = ½ \times (P_{mab} + P_{mib}) = ½ \times (2{,}210 \times P_{mib} + P_{mib}) = ½ \times P_{mib} \times (2{,}210 + 1)$$

$$P_{avb} = 1{,}605 \times P_{mib}.$$

By the application of the equations for the average load and the maximum load the load factor can be determined.

$$l_b = P_{avb} / P_{mab} = 1{,}605 \times P_{mib} / 2{,}210 \times P_{mib} = 0{,}726.$$

This load factor „l_b" is only slightly higher than the load factor „l_t"of the total power station capacity. During the period of time since 1984 the base load units have not really been operated as such. The evolution of the load factor as a function of time during the aforementioned years indicates, however, a clear upward trend *[ATT 4 - 4 & 5]*. This trend is possibly related to the commissioning schedule of the base load capacity in the Mainland Grid of Greece. Between 1984 and 1987 the Amyntaion and Agios Dimitrios power stations have been commissioning. This corresponds to a yearly capacity increment of

455 [MW/a]

In 1991 the unit IV in the LCM started operation. Between 1988 and 1994 the base load capacity increased only by

25 [MW/a].

From our point of view higher load factors than observed in the past must be achievable. The load duration curve is possibly influenced by the quick built up of the base load capacity in the past. In this context it is important to mention, that in the year from September 1994 until August 1995 a load factor of

$l_b = 0{,}849$ *[ATT 37 - 29]*

has been achieved.

1.1.1.5.2 Individual Power Stations

The seasonal variation of the gross generation of PPC s lignite fired power stations has been investigated for the years 1990 - 1995 (Jan. - Aug.).

As an indicator for the seasonal changes of the load we calculated the quotient monthly gross generation divided by the yearly gross generation for each month in the aforementioned period of time. the result is shown in the form of diagrams in the attachments *[ATT 23 - 03, 07, 11, 15, 19, 23 & 27]*.

There are two load peaks during the year. One in the winter (November - February) and the other in the summer (July - August). The height of the peaks is less than the depth of the valleys (Planned maintenance of the power station units during the valley periods).

This effect is important for the stockpile management. The quantity of lignite may decrease during the peak periods. The following valley period will allow to fill up the stockpiles again.

1.1.1.6 Base Load Units, Net Generation, Reserves, Utilisation

The actual evolution of the net generation of the base load units in the Mainland Grid of Greece is shown in attachment *[ATT 4 - 2]*. As the net generation NG_l increased steadily until 1994 and the installed capacity P_{inb} did not increase correspondingly, the utilisation of the base load capacity increased. In 1994 a utilisation of

$u_l = 0{,}7347$

has been achieved. We regard this as a favourable development. Due to economical reasons -base load power stations are characterised by high fixed and low variable cost fractions- the utilisation of base load units should be between 0,700 and 0,800.

The future evolution of the net generation and of the installed capacity of the base load units results, however, again to a reduction of the utilisation. Until 2020 an average utilisation

$u_l = 0{,}6895$ *[ATT 5 - 14]*.

is achieved. The average utilisation of the lignite fired units in The LCPA and the LCM until 2020 will be

$u_l = 0{,}6828$ *[ATT 5 - 9]*

A graphical representation of the past and future evolution of the utilisation of the base load units in the Mainland Grid of Greece is shown in *[ATT 4 - 9]*.

As we see it, the future utilisation of the base load units has been underestimated. The evolution of the actual figures during the months January until August support this point of view *[ATT 37 - 4, 8, 12, 16, 20, 24 & 28]*.

If, however, a higher utilisation of the power station capacity is achievable, the increment of the power station capacity should not be as much as to reduce the utilisation of the installed capacity.

For the preparation of the TMMP we are to assume, that the utilisation of the power station capacity might be higher in future than assumed up to now.

Hence an alternative scenario has been developed by the Masterplan Team. The decommisioning of lignite fired units due to the restricted reserves *[SCT 1.1.7]*. has already been taken into account in this scenario, which can only be the first proposal for discussions with the Division of Generation and with the Direction of Programming and Strategic Planning:

- Our design of the future load distribution curve for the base load units starts with the minimum load P_{mib}''. In order to achieve the highest possible net generation by the base load units we set P_{mib}'' equal to P_{mit}'''.

  $P_{mib}'' = P_{mit}'''$ *[ATT 4 - 3 & 5]*
- The load factor l_b'' has been set conservatively compared to figures, which have already been achieved at

  $l_b'' = 0{,}800$.
- The average load P_{avb}'' can be calculated as follows, if we assume a simplified load duration curve as described before.

  $P_{avb}'' = P_{mib}'' / (2 - 1 / l_b'')$ *[ATT 4 - 5]*.
- The maximum load P_{mab}'' is then the average load P_{avb}'' divided by the load factor l_b''.

  $P_{mab}'' = P_{avb}'' / l_b''$ *[ATT 4 - 5]*.

  The installed P_{inb}'' has been adjusted according to the reserve factor r_b''. We adopted the strategy to keep the reserve factor above 1,300 or at least slightly below this figure. as soon as this condition was no more fulfilled, the next base load unit has been added. Due to considerations referring to the primary regulation of the frequency in the Mainland grid, a maximum unit size of 300 [MW] is maintained *[ATT 2 - 10]*.
- Finally the achievable net generation NG_b'' is calculated as the product of the average load and the calendar time.
- The utilisation of the base load units is the result of the load factor l_b'' and the reserve factor r_b''

  $u_b'' = l_b'' / r_b''$

The alternative TMMP *[ATT 4 - 5]* scenario described above results in a higher accumulated generation of the base load units, which can be achieved with lesser installed capacity. Only a fraction of the lignite fired base load units (300 [MW]), which are taken out of operation due to the restricted remaining lignite reserves, is to be replaced in the year 2018 *[ATT 2 - 10 & 11]* by a new base load unit, which has not been scheduled up to now.

From our point of view, there are reasons, to take this proposal into account. If our considerations apply, a higher lignite demand compared to PPC s present proposal is the consequence. The preparation of our alternative scenario has been initiated by discussions of this matter with the LCPA based on the actual figures for the first 8 months of 1995.

The necessary review of the TMMP cannot be executed as part of our work, because the TMMP-contract will expire at the end of the year 1995. We suggest to review the future lignite, and to adjust the long term concept of development of PPC s mines as required afterwards.

1.1.1.7 The Operation Schedule for the Power Stations

The schedule of operation for the power station units in the LCPA and the LCM is to be adjusted to the remaining heat reserves in PPC s lignite mines. These reserves are calculated in *[SCT 1.2.6]* of this report. They have been assigned to the next power station, in order to avoid costly lignite transportation as far as possible. The requirements Of thermal energy for PPC s lignite fired units, which will be used below, are determined in *[SCT 1.1.6]*.

In the attachments *[ATT 6 - 1 / 2]* the duration of the operation of PPC s lignite fired units in the LCPA and the LCM has been calculated if only the units I and II of the Megalopolis A power station are shut down in 2011 prior to the exhaustion of the lignite reserves.

A third unit of the Amyntaion power station is commencing operation in 2007. The power station units in the LCPA and in the LCM are then operated until the reserves in PCP s lignite mines are completely exhausted.

The results of these calculations have been comprised in attachment *[ATT 6 - 3 & 4]*. An average duration of operation of

47,1 ± 10,4 [a]

is achieved. The older and smaller units, which are generally characterised by higher specific requirements of thermal energy, operate longer than the bigger and younger units, which consume less calorific energy. The power stations Kardia, Liptol and Ptolemais are then to stop operation in 2016. The Amyntaion units run out of lignite in 2025. The units Megalopolis A III and Megalopolis B IV will be decommissioned in 2029 and the five units of Agios Dimitrios are to be closed down in 2043.

This is not the most favourable approach. The average duration of operation is reduced. The unit III in Amyntaion will operate for 19 years only. and the units III and IV of Kardia will achieve operation times of 37 and 36 years only. On the side of the mines the lignite demand remains high until 2016. As the mining ratio will be continuously increasing until then, investments for additional mining equipment are inevitable.

By the application of another strategy these disadvantages can be reduced. In the attachments *[ATT 6 - 5 & 6]* the equal total operation time has been calculated, that results to the remaining reserves of calorific energy, which have been assigned to the power stations in order to reduce the transportation distances for lignite as far as possible. Additionally we have assumed, that no third unit is erected in the Amyntaion power station.

The results of these calculations have been comprised in *[ATT 6 - 7 & 8]*. The average duration of operation has increased to

50,1 ± 6,1 [a].

The power station investments especially of the newer units are utilised in a more economical way and the investments for replacement capacity are distributed over a longer period of time. The decommissioning of the power station capacity starts with the units Liptol I and Ptolemais I in 2009 already. From then onward the decreasing lignite demand and the increasing mining ratio help, to avoid investments for additional mine equipment.

The operation time for the Kardia power station is, however, 10,1 [a] shorter than the average whereas the operation time of Agios Dimitrios is 8,2 [a] longer. The units Ptolemais IV, Agios Dimitrios V and Megalopolis B (IV) operate considerably longer than the other units of these power stations. For the operation of these last units the complete infrastructure of the power stations is to be maintained. The same applies to the lignite mines. This is not as economical as possible. Further improvements are necessary.

In the attachments *[ATT 6 - 9 & 10]* we have adjusted the operation schedule of the power stations, in order to remove the aforementioned disadvantages. The extended lifetime of the Kardia power station is achieved by the transportation of lignite from the South Field to the Kardia power station.

Resulting to the adjustment of the operation schedule of the lignite fired units in the LCPA and in the LCM the base load capacity in the Mainland Grid is reduced considerably. The variant 3 is however not yet our final proposal. There are options, to increase the remaining reserves by technical changes in the power stations. A small fraction of the lignite supply could be dried, to raise the calorific value of this part of the lignite supply. By blending this fraction of the lignite supply, which has now an increased calorific value, with the remaining lignite supply a calorific value above the minimum value in the specification for design purposes *[SCT 1.1.3]* is to be achieved. As a consequence of the higher calorific value of the fraction of dried lignite a corresponding lower calorific value of the remaining lignite supply can be accepted.

During the masscalculations for the TMMP we learnt, that this reduction of the acceptable calorific value of the mine production will result in increasing reserves of exploitable calorific energy and a decreasing ratio especially in mine areas close to the perimeter of the deposit (West Field North, Sector 6 & West Field South).

The lignite from these fields is supplied to power stations with a high lower limit for the calorific value in the lignite specification for design purposes. The cut off ash content is to be set at a low figure and the reserves are correspondingly low at present.

There are two options, to dry lignite. The boilers in the power stations can be equipped with so called steam separators (As in the Megalopolis power stations) or separate drying facilities could be installed, which are already available in the Liptol power station for the Liptol and Ptolemais power stations.

If this strategy is applied systematically, the reserves of the following mines in the LCPA will change *[SCT 1.2.4.1]*.:

- North Field,
- Komanos,
- West Field North,
- Sector 6 & West Field South.

The present schedule for the operation of the lignite fired power stations is to be reviewed according to the result of discussions between the Division of Mines DAO), the Division of Generation and the Direction of Programming and Strategic Planning.

1.1.2 The Specific Energy Requirements

The specific energy requirements for the generation of electric energy are another important input parameter for the determination of the lignite demand.

These figures have been calculated in attachment *[ATT 7 - 1 / 8]* based on the actual fuel consumption and generation figures. This calculation calls needs some comment:

The actual data for the calculation did not include any information about the quality of the lignite. The lignite quality is a calculation result wit the quality parameters for the mixture of different fuels and the quality parameters of the components of this mixture except the lignite as input.

As we see it, regular measurements of the actual lignite quality were a much better method for the determination of the lignite quality.

It will be shown later *[SCT 1.2.6]*, that only then the actual production figures can be kept close to the masscalculation results. On the other hand the accuracy of the specific energy requirements calls for the knowledge of the calorific value of the lignite as the main fuel for PPC s lignite fired power stations.

We suggest to install a station for lignite sampling and quality analysis in the lignite handling system of each mine.

The data base for the aforementioned calculation is small in the case of the Amyntaion and Megalopolis power stations.

In the case of the Liptol power station we did not succeed in collecting the data for the separation of the heat requirements for the generation of electricity and for the drying of lignite in the briquetting plant. The specific heat requirements for this power station presented in attachment *[ATT 7 - 1]* include the energy consumption for the production of dry lignite in the Liptol briquetting plant and is for sure too high. Hence we have introduced an assessed figure for the specific energy requirements of the Liptol power station for the Generation of electric energy.

In attachment *[ATT 7 - 8]* the results of our investigation are compared to PPC s assessment of the specific energy requirements. The upper and the lower limit, determined by the Masterplan Team are closer to each other than the corresponding PPC figures. The average figures in the TMMP analysis are lower than the PPC figures.

Our analysis should be actualised regularly. as soon as possible actual quality figures for each mine are to be introduced into this analysis.

The older and smaller units have higher specific energy requirements than the newer and bigger units. The pending legislation referring to the emission of CO_2 is a reason to replace older and smaller units, in order to reduce the emission of CO_2 by reducing the average specific energy requirements *[SCT 1.1.1.7]*

1.1.3 The Lignite Quality Requirements

The lignite, supplied by PPC s opencast mines must correspond to the quality requirements of the power stations. The lignite specification for the design of PPC s lignite fired units is presented in *[ATT 8 - 2]*.

The ash content is referred on as received basis by the power stations. In the mines the ash content is referred on dry matter basis. Additionally all power stations except Amyntaion use an ash content excluding carbon dioxide. Only Amyntaion applies an ash content including carbon dioxide.

These differences make the handling and evaluation of the quality data unnecessarily complicated. They are the reason for evitable mistakes.

In order to remove the problems related to the different quality parameters, described above we have transformed the ash content in the original specification for design purposes to the ash content based on dry matter, including the carbondioxide. The lower limit of the ash- and water-content should be related to the upper limit of the calorific value in the spedification of the Power station and vice versa.

This assumption has been checked in attachment *[ATT 8 - 2]*. The minimum ash- and water-content result, however, in a calorific value above the maximum calorific value in the specification of the power stations and vice versa.

According to this calculation the lignite specification for design purposes is no guideline for the operation of the lignite mines of PPC. Hence the steering of the exploitation requires another set of lignite quality data.

In the attachments *[ATT 8 - 3 / 20]* a lignite specification for mine operation purposes is presented in the form of tables and diagrams.

The diagrams show the ash content (waterfree, carbondioxide included) on the x-axis. The y-axis represents the watercontent. By the application of the formula for the calculation of the calorific value, introduced by the Masterplan Team *[SCT 1.2.4.1.5]* the ash- and water content data sets have been determined, which result in the upper or lower limit of the calorific value in the lignite specification for design purposes. The upper curve represents the lower limit of the calorific value and vice versa. The ash and water content figures of the mine production must be kept between these curves.

At the same time the limits for the ash and watercontent must not be exceeded. They are shown in the diagrams as far as necessary as vertical or horizontal lines.

The actual lignite quality during the years 1983 - 1993 is shown for the Ptolemais power station. The actual ash-content figures are important in this case for the judgement of proposals, to reduce the dilutions and the accumulated thicknessof losses and dilutions in the West Field North. The future quality of the reserves, assigned to each power station, are shown presented additionally.

There are options to increase the lignite reserves by accepting a calorific value of the mine production below the specified value and blending the mine production with other fuels. A favourable option is in this context, to dry a small fraction of the mine procuction for blending purposes. This applies to the Ptolemais-, Kardia- and Amyntaion power stations. For these power stations a second diagram has been prepared, where the lower limit of the calorific value has been assumed

100 [kcaql /kg]

lower than in the specicification of the power stations.

These diagrams are an tool not only during the planning phase but for the operation of the PPC mines as well.

In both cases a feed back mechanism is applied, to keep the planned or actual lignite quality between the limits.

In the planning phase the cut off ash content is to be adjusted until the average quality parameters, achieved in the subsequent masscalculation are between their limits. Normally it is sufficient, to take care of the calorific value. If this figure is kept between the upper and the lower limit, as close as possible to the lower limit, the ash- and water content will be kept between their limits as well. By presenting the calculated quality parameters in the diagrams described above, the masscalculations can be steered appropriately. The potential effects of lignite drying can also be assessed easily in these diagrams *[SCT 1.2.4.1]*

During the exploitation of PPC s multi layer deposits the actual lignite quality can only be kept close to the masscalculation results by steering the selective excavation of intercalation- and lignite blocks by the application of another feed back circle. in this case the actual lignite quality is used as an indicator, to include or exclude layers with higher ash content into the lignite or to vary the mining losses and dilutions, resulting in the total inaccuracy of the process of selective mining based on the judgement of the operators of the BWE s *[SCT 4.1.1]*.

1.1.4 Conclusions, Lignite Demand

All basic data for the determination of the fuel demand of the lignite fired power stations and for the judgement of these figures are now complete.

The lignite demand as the possibly most important input parameter can now be determined as follows *[ATT 9,10 & 11]*.

- The yearly consumption of thermal energy is determined in based on the utilisation of the lignite fired base load capacity in the LCPA and the LCM and the specific energy requirements of each power station *[ATT 9]*.
- The corresponding lignite consumption figures are comprised power station wise, to show how the mines contribute to the demand of the power stations *[ATT - 10]*. They are the result of the production scheduling carried out in *[SCT 2.3.2]* of this report.
- In *[ATT 11]* the production schedules have been comprised mine wise, to show how the mine production is distributed to the power stations.
- The lignite production schedules of the individual mines result in the lignite production schedule for the LCPA, the LCM and the schedule for the accumulated total lignite

quantities. These schedules are presented as table and diagram in attachment *[ATT 12 - 1 & 2]*.

The following comment is required in context with the evolution of the lignite demand presented above:

- The utilisation of the power stations has been underestimated and the capacity of the base load units is most likely built up too quickly *[SCT 1.1.1.6]*.
- The capacity of the power stations in the LCPA might not decrease as quickly as assumed for the determination of the lignite demand up to now *[SCT1.1.17 & 1.2.4.1]*, because increasing reserves could allow, to operate the power stations longer than assumed up to now.
- The specific energy requirements for the generation of electricity assumed up to now have been determined with calculated lignite properties. Regular measurements of the calorific value of the lignite might be more accurate. Adjustments of the specific energy requirements could become necessary *[SCT 1.1.2]*.

The lignite demand assumed at present is not regarded as a sufficiently accurate base for the preparation of the TMMP. A review of this important basic input for this kind of planning work is recommended. Subsequently the long-term concept of development for PCP s lignite centres is to be adjusted as required.

1.2 Remaining Reserves & Mining Ratio

PPC s mines have to deliver a certain amount of calorific energy to the power plants year by year. This must be guaranteed by the mining equipment in operation. In this chapter all data will be analysed, which are necessary,

- to determine the mining ratio and
- which are the basis for the calculation of waste quantities and lignite quantities and qualities.

In this context this is essential:

PPC s lignite deposits, especially in the LCPA and there especially in the areas close to the perimeter of the deposit are built up by a multitude of lignite and waste layers, which have up to now not been correlated.

The quality of a fraction of these layers has not been analysed. This applies to all intercalations some layers specified as lignite and the lignite and waste layers in the sections of the drillholes, where no core has been obtained. For the calculation of average quality figures it is, however, necessary, to know the ash-, water. and lime content of all layers, which can be part of a lignite block.

In these cases quality parameters had to be assumed for the calculation of the average quality parameters. Intercalations thinner than the minimum thickness for selective mining are included in lignite blocks, and the intercalations on top and below a lignite block are blended with the lignite due to the inaccuracy of the selective mining (Dilutions).

In PPC s multi layer deposits one should not expect clear differences referring to the ash content or the calorific value between waste and lignite. Both parameters vary between wide limits. The setting of the cut off ash content influences the average calorific value and the lignite reserves much more than usually.

The following Subjects are to be dealt with in this section:

- Geological Investigations
- Hydrological Investigations
- Geotechnical Investigations
- Masscalculations
- Conclusions: Reserves and Mining Ratio

1.2.1 Geological Investigations

Geological facts are an important basis for many items of the planning work of the TMMP. Accordingly the investigation and evaluation of the geology is essential for this task.

This statement is supported by the following remarks:

The accuracy of the masscalculations depends on the accuracy of the geological data base (Stratigraphical and tectonical structure of the deposit).

Hydrological investigations call for the knowledge of the geology.

The geotechnical analysis of the slope stability requires the results of both aforementioned subjects. Especially in deeper mines the inclination of the perimeter slope of the mine and the external dump, of the operational slope systems on the excavation and dumping site and of the permanent slopes in the final void, influence the mining ratio and the average distance of transportation considerably.

Corresponding to these considerations the costs of the lignite are influenced by the quality of the geotechnical analysis, which depends on the quality of the geo-hydrological input information.

The following subjects will be dealt with in this report under the headline " Geological Investigations:

- The Future Drilling Program
- Hardrock Mapping
- Evaluation of the Geological Model in by Drawings

1.2.1.1 The Future Drilling Requirements

In context with the preparation of the Technical Mine Master Plan for the two Greek lignite mining centres LCPA (Macedonia) and LCM (Peloponnesus) it is to be clarified whether supplementary drill holes for deposit exploration will be necessary. The mining fields to be considered are those of Ptolemais South Field, Sector 6, with the adjacent southern part of the West Field, the northern part of the West Field, Proastio and Amyntaion in the LCPA *[ATT 13 - 1 & 2]*, and the Khoremi mining fields, including Marathoussa and Kyparissia in the LCM *[ATT 13 - 3]*.

The decision in favour of additional drill holes is to condense the available deposit-specific information such that drillhole-secured statements can be made in respect of the lignite seams' formation, extension and quality and the bedding conditions, including tectonics. The geological representations must be sufficient to permit geomechanical and hydrological investigations. Together with the deposit, the definition of the opencast mine's final slopes and depths forms the basis for long-term planning and reliable assessment of the mineable deposit resources.

The following documents were available for this task *[SCT 7.1]*:

- Drilling maps of the mining fields,
- sections with non-correlated representations of lignite seams and associated strata in drill holes without data on the associated strata's type and structure,
- older correlated geological sections on different scales showing the mining fields Amytaion, West Field (northern and southern parts) and Khoremi/Marathoussa.

All mining fields to be investigated have so far been explored with one or several drilling programmes. *[ATT 13 - 4]* gives a survey of the present, very different exploration situations in the two mining areas.

The proposal is made to continue optimising the existing drillhole networks in additional condensation steps until the findings will fulfill the requirements of medium-term mine planning. Surveys and samplings in the opencast mines are to further refine the geological representations in order to be available as a basis for short term planning also in respect of the lignite qualities required. In this context we would like to mention, that the calculation of the average quality parameters of the lignite requires quality figurres for all layers, which become part of the exploitable lignite blocks during the evaluation of the drilling results. All layers from the waste atop the uppermost lignite layer to the waste layer below the deepest lignite layer must be analysed. The present conservative assumptions for the quality of the strata without analysis must be substituted by analysis results as soon as possible, to improve the accuracy of the reserve calclulations.

The supplementary drill holes suggested in this report will concentrate on mining field parts where the deposit data are not sufficient for long-term planning, and on hardly explored marginal zones where the assessment of the final slopes' stability will call for an exact representation of the bedding conditions. Seen on the whole, the next exploratory step will require 228 drill holes. After evaluation of the drill holes suggested, further exploratory steps are expected to be necessary in the future.

The data on piezometer installation into drill holes are given in agreement with RE s expert in the field of hydrology (Dr. Voigt).

In general, it is necessary to correlate (after the drilling of new drill holes) all the available drillhole data and update all deposit-specific representations, i.e. the geological sections and the contour maps of the deposit areas, so as to show the latest situation in each case. This activity is expected not only to improve the accuracy of the geometrical representations of the PPC deposits. Additionally it will allow, to substitute the missing quality information in the case of core losses.

1.2.1.1.1 Process to Optimise Deposit Exploration and Representation

This process includes the application of two tools. The Network of drill holes is to be optimised stepwise in subsequent phases of drilling and interpretation oft drilling results. the second tool, to be applied is the regular survey of the excavation faces (face mapping).

1.2.1.1.1.1 Optimisation of the Drillhole Network

With the object of avoiding inadequate exploration, but also inefficient excess exploration, the drillhole network shall be optimised in several exploratory steps. Between the individual steps, the geological projection shall be revised so that for the determination of the locations of drill holes still to be drilled the results obtained from the preceding drill holes will have already been taken into account.

During each condensing step, it is examined with what accuracy the drillhole results were predicted by means of the geological projection. On the basis of statistical evaluations made of the test results after each exploratory step it can finally be predicted at what drillhole density the planned representation accuracy can be expected.

Thus, the drillhole density is variably adjusted to the degree of difficulty involved in the geological conditions. In this way, the density of the drillhole network can also be adjusted to the respective planning stage. So, the drillhole network in the fields being exploited is more close-meshed than that in the mining fields that will be developed only in the next few years or decades. Even within the fields being extracted the drillhole density is graduated, depending upon the mining operations' approach in terms of time and space.

The representation accuracy required for mid term planning, which should be a determining factor for the final drillhole density (viz. for the area that will be affected by mining operations in the next five years) can be defined as follows:

- The bedding conditions are to be explored to such an extent as will permit drillhole-secured representations (sections) for geomechanical and hydrological investigations.
- The seam thicknesses are to be determined by drill holes to such an extent as will ensure mass calculations for annual sections with accuracies of ± 5 %.
- The lignite qualities are to be explored to such an extent as will permit exact statements on the most important quality parameters and determination of the occurring content of thermal energy with an accuracy of ± 5 %.

1.2.1.1.1.2 Optimisation of Exploration by Means of Geological Mine Surveys:

The considerably higher accuracy requirements for detailed planning of excavator operation, including quality control, can only be met by an uneconomical drilling expense, or (more favourably in terms of costs) by geological opencast mine surveys. These surveys are made after each cutting. This opencast mine survey includes logging of all mining-relevant data (mainly tectonics, layer boundaries and consolidated layers), sampling of lignite and associated strata as as correction and supplementation of the existing geological representations and documents.

1.2.1.1.1.3 Drilling Techniques, Geophysical Borehole Logging

The exploratory drill holes drilled so far are almost exclusively core holes. According to the information supplied by ΓΑΕ, core losses of approx. 30 % occurred in the overburden, and approx. 10 % was encountered in the lignite bearing series during drilling.

Major part of the supplementary drill holes proposed are located in the marginal zones of the mining fields and primarily serve to prepare geological sections, which in turn are used to assess the final slopes' stability. Preparation of these sections calls for correlation and projection of all penetrated layers, i. e. the overburden strata, the lignite series and the footwall.

In order to carry out a reliable correlation of the layers despite the occurring core losses it is recommended exploring the supplementary drill holes by means of geophysical logging. Due to the better comparability with the existing drill holes, 40 % of the proposed drill holes should likewise be sunk according to the core drilling technique. In addition, the cores obtained from the lignite should be used to assess the lignite quality, and the cores from cohesive layers in the opencast mine's marginal zones should serve for geomechanical investigations.

The following geophysical borehole logging should be made:

1. Measurement of the natural gamma rays (with breakdown of the gamma-ray spectrum (Natural Gamma Ray Spectroscopy) into uranium, thorium and potassium).
2. Induction logging: The application of induction logging should be considered in order to determine especially thin layers (thin bed resistivity tool).
3. Density logging with an active source in connection with caliper logging.
4. Hole deviation loggings for drill holes with greater depths (> 250 m).

It is recommended calling geophysical companies in, which are capable of carrying out high-quality loggings.

The use of geophysical measurements is expected to result in core drilling being still more reduced in the future after completion of the drill holes proposed in this investigation. This, however, will require a reliable correlation between the logs of the geophysical measurements and the lithological identification from core holes. For the extraction of drill cores for lignite quality analyses and geomechanical investigations, however, a few core holes will still be necessary.

All drill holes should completely be sunk through the lignite-bearing series and reach down to approx. 10 - 20 m into the footwall (white marl horizon). The drill holes near the mountain front (West Field) should partly be drilled down to the pre tertiary rocks.

1.2.1.1.2 Exploratory Situation and Drilling Programmes

During the determination of drillhole spacing and preparation of the proposals in respect of supplementary drill holes, the zones within the planned mine boundaries plus an marginal strip at the mine rims of about 200m width were considered in each mining field. It was above all the exploitation of the deeper deposit parts that called for investigations of the slope stability, in particular that of the opencast mine rim slopes. This requires the exact knowledge not only of the bedding conditions in the opencast mine, but also in respect of a safety margin outside the mine rim, which will approximately correspond to the mine depth.

The drilling locations of the planned drill holes were determined, with the greatest possible account being taken of the topography. In order to adjust them to the local conditions, their positions can slightly be shifted without impairment of the results.

The proposals to drill the exploratory drill holes are based on the assumption that the existing drill holes plotted in the drilling maps are complete. Should there be any other drill holes, the proposals are to be modified, if necessary.

(=16drill holes/km^2) have so far been drilled. Major part of the drill holes are arranged in cross sections and / or longitudinal sections. The cross-sectional direction is SW-NE. The spacing of the individual sections amounts to 200 m, and in the marginal zones of the mining field it is 400 m. The spacing of the drill holes on the sectional lines ranges between 200 and 400 m.

While the maximum drillhole density in the vicinity of the opencast mine amounts to approx. 20 drill holes / km^2, it regionally decreases to < 10 drill holes / km^2 in the northeast and southeast of the planned mining field. The final slope area, incl. the safety margin, also includes only a few drill holes. The drillhole density, incl. the rim slope, totals approx. 11 drill holes/km^2.

Proposals for Supplementary Drill holes *[ATT 13 - 5]* :
The safe operation of the opencast mine calls for the stability of the operational slopes and above all of the final slopes. Therefore, the drillhole distance should be reduced in sections 280, 296, etc., each being 800 m apart. This will require a total of 48 drill hole. After the evaluation of the drill holes, correlation and representation of the bedding conditions (dip and position of faults and dip of strata) for geomechanical and hydrological assessments, the drillhole grid should be optimised such that further condensation steps in the final slope area will be taken where faults and dipping layers require a higher information density. The cross sections for geomechanical investigations must be arranged rectangularly to the course of the final slope system.

The relatively densely explored mining field requires only two additional drill holes at present in the southeast to clarify the bedding conditions there. The drillhole network should be condensed in further steps only when the opencast mine will approach.

Due to the still favourable overburden (incl. intercalations)-to-lignite ratio in the western extended area of the mining field up to the Kardia power station it is recommended that this area (sector 4) should, for the moment, be explored in greater detail with nine drill holes in view of a possible mine rim shift to the west. This extension, however, would require a relocation of the Soulou creek.

Depending upon the strata sequence especially in the tectonically stressed marginal zones, approx. 30% of the drill holes are to be converted into observation drill holes.

1.2.1.1.2.1.2 LCPA: Sector 6 and West Field South

In the southeast the Sector 6 mining field (without West Field) borders on the South Field opencast mine. It extends approx. 4 km towards the N-SE. In the central and northern parts of the mining field, the Sector 6 opencast mine has been developed where at present the lignite pillar is being mined in an eastward slewing mode towards the former Kardia opencast mine. West of the opencast mine the outside dump of the former Kardia mine is located. With approximately the same size as the mining field of Sector 6, the southern part of the West Field follows in a south-western direction. It extends from the Kardia power station in the southeast to a zone of considerably increased overburden / lignite ratios in the northwest, which constitutes a boundary towards the northern part of the West Field. Without the developed opencast mine, the entire mining field extends over a total of approx. 14.5 km^2. In the south-western marginal zone there is the Pontokomi village, major part of which is situated in the future mining area.

Description of the Deposit:

Except for some areas in the centre and in the northwest, the deposit of the mining field has a similar form as the South Field. Faults striking from WNW-ESE to NW-SE dissect the mining field into several fault blocks. The western rim of the mining field is located near the mountain front. Behind faults running almost parallel to the mountain front and dipping towards the basin, i.e. the planned opencast mine, pre-Tertiary slates and limestone layers reach the ground surface outside the mining field. In these areas, the layers can also dip towards the mine.

The thickness of the lignite-bearing layers, including intercalations, mainly ranges between 80 and 140 m. In a narrow „graben", part of which simultaneously forms the south-western boundary of the mining field, the lignite-bearing layers increase to a thickness of more than 210 m. The depth of the bottom lignite layers here reaches approx. 360 m. In the central and north-western parts of the mining field the thickness of the individual split seams, which are partly replaced by intercalations, is subjected to major variations. Without account taken of mining losses, the overburden-to-lignite ratios range here from 5:1 to > 10:1. Without the outside dump, the overlying strata thicknesses vary between approx. 20 and 60 m. In the above „graben" zone, they amount to approx. 150 m, with the upper half being probably accounted for by water-filled sandy and gravelly layers.

In the central part of the mining field the layers are flat or somewhat inclined with changing dipping directions. It is only near faults and in areas with changing split seam thicknesses that the layers can dip more steeply due to bending caused by differentiated peat settlement.

The available documents (sections) of the West Field show that consolidated intercalations occur in places in the gravel and sand layers of the Proastio series.

Current Exploratory Situation in the Deposit:

The drillhole densities in the mining field differ considerably. The highest drillhole density can be found in the transition zone to the South Field with up to 20 drill holes / km^2. The same applies to the southern part of the opencast mine. Only a few drill holes were drilled in the zone covered by the outside dump. The southern part of the West Field was explored by an almost square drillhole grid with drillhole distances of approx. 400 m, which in a few places was condensed by further drill holes (5 - 10 drill holes / km^2). In the south of the West Field and in a 200 m wide safety margin around the southern part of the West Field drill holes have so far been drilled at long intervals only. Seen as a whole, the drillhole density averages approx. 9 drill holes/km^2.

Proposals for Supplementary Drill holes *[ATT 13 - 6]*. :

The existing drillhole network does not suffice in view of long-term mine planning. This in particular applies to the slightly explored bedding conditions in the area of the western rim slope. The bedding of the layers will have a crucial influence on the decision to which depth the lignite layers deposited in the above graben can be extracted. Therefore, the proposal is made to drill supplementary drill holes in order to obtain more detailed data on the tectonics and the dip of layers in the specified section positions and prepare geological sections for the geomechanical assessment of the slope system. This will first require 14 drill holes, 10 of which should be drilled down to the basement strata.

With the object of exploring the deposit below the outside dump and better delimiting the zone with the considerably reduced thicknesses of the split seams, a total of 23 drill holes is proposed in the central part of the mining field, which will permit a drillhole-secured assessment of the deposit resources. These drill holes are also necessary to clear up the differences in the lignite thicknesses of drill holes lying close to each other (e.g. 236/247 to D 482, 228/246 to D 484).

Of the approx. 20 drill holes proposed along the SW rim, 8 - 10 drill holes are to be converted into piezometers. Several of these drill holes are to be planned for use as multiport piezometers.

1.2.1.1.2.1.3 LCPA: West Field North

The northern part of the West Field covers approx. 11 km^2, plus a safety margin of approx. 1.5 km^2 in the area of the western final slopes. In the NW-SE direction, it extends over approx. 5 km from the Ptolemais power station to the Komanos village and in the NE-SW direction from the former opencast mines, viz. Main Field and Komanos, to the mountain front where pre-Tertiary slates and limestone layers occur near the surface. The mining field includes outside dump I and administrative buildings of the opencast mines, industrial facilities and parts of the Ptolemais power station. Outside the planned mining area, the Mavropigi village is located in the southwest of the field.

Description of the Deposit

The layer formation differs considerably in the mining field. After a zone of very small thicknesses of the lignite-bearing series in the south (see southern part of the West Field), the

1.2.1.2 Mapping of Hard Layers

Hard rocks, i. e., mostly conglomerates and sandstones, seem to occur in most mines of LCPA. Visual inspections reveal them to consist of cobbles, pebbles, and sand grains, cemented by calcium carbonate. Most, if not all, hard rocks have been found embedded in Quaternary unconsolidated sediments. So far, it has not yet been possible to map their occurrences in the mines in advance to a degree that would be sufficient to meet planning requirements.

Mapping of exploratory holes *[SCT 7.3 - 01 -4 / 5]* [3] has proven, to result in no reliable information about the hard rock formation.

There are two reasons contributing to this effect. The hard layers in lignite deposits tend to disintegrate to loose material in the drillhole on the one hand. On the other hand exploration drill holes do not even hit the hard material in any case. If the hard material occurs in the form of lenses or boulders, it will be detected by exploration boreholes only occasionally.

It might be possible to predict their sites of occurrence in the areas forward a mine if their mode of formation is understood. It is obvious that they developed by $CaCO_3$ precipitating within a deposit of water saturated unconsolidated rocks.

A possible hypothesis explains their occurrence as follows:
Ground water, being saturated or even over saturated with dissolved calcium hydrogen carbonate $Ca(HCO_3)_2$, leaves an adjacent karstic terrain and enters the basin fill of unconsolidated strata. High permeability strata such as sands and gravels are the preferred zones of ground water flow.

During its residence in the generally shallow basin aquifers, ground water warms up, gaseous carbon dioxide evaporates and calcium carbonate precipitates according to the formula:

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + CO_2 \uparrow + H_2O$$

If the critical temperature was reached in a deposit of gravel, a conglomerate formed. sand became sandstone, and silt became silt stone. Carbonate is the cementing agent.

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[3] See Section 7.4 - N° 3

If it is possible to plot the already excavated and the known, but still existing hard rock layers in the mines along with water table contour lines of the Quaternary aquifer, it might be possible to establish a recognisable pattern of occurrence, say a certain distance from the karstic mountain front. Should this approach be successful, it might be possible to predict hard rock layers as yet undetected.

Generally spoken it is essential, to investigate the genetic conditions, which result to hard layers. The knowledge of these conditions allows, to determine the areas in the deposit, where one should expect hard layers. These areas are then to be investigated in detail by other means. Due to the time requirements this activity, there was no possibility to include this activity into the TMMP.

Another appropriate tool for the exploration of hard layers in a lignite deposit are geophysical logging methods -the higher density of the hard material compared to the soft strata indicates the presence of hard layers *[SCT 7.3 - 1 - 4 / 5]*.

The inspection of the open faces in the mine (face mapping) whenever a fresh excavation face has been exposed and shallow boreholes an the benches of the excavation site are the measures to be carried out for a more precise short term exploration of the hard layers.

For the preparation of the TMMP the not yet correlated drilling results, which have been included into the geological model *[SCT 1.2.1.1]* were available only. This data base was not sufficient for the task of hard rock mapping.

The yearly hard rock removal figures, which are mentioned in our production schedules, result to PPC s present knowledge of this matter. For the South Field the distribution of hard rock material is presented in attachment *[ATT 14 - 1 & 2]*. For the other mines of the LCPA the following fractions of the total waste have been assumed as hard rock material:

- Amyntaion : 4 %
- North Field : --
- Komanos : 5 %
- Sector 6 & West Field North : 10 %

This is only a rough assessment, which calls for a more detailed analysis.

A more accurate determination of the hard rock deposits in PPC s mines is a part of the follow up activities, referring to the deposit characteristics *[SCT 1.2.5]*.

1.2.1.3 Geological Evaluations (Maps, Cross Sections)

The contract stipulates numerous graphical evaluations of the geological model as any kind of geological maps and cross sections.

A major advantage of the availability of a computer aided geological model is, that this kind of evaluations can be prepared and actualised as required.

As far as these maps and cross sections were necessary for the preparation of the TMMP we have used this possibility. These drawings are included in the list of drawings *[SCT 7.2]*.

The drawings, not listed in *[SCT 7.2]* but mentioned in the contract can easily be prepared with PPC s masscalculation software based on the geological model, prepared by the Masterplan Team.

1.2.2 Hydrological Investigations

In the LCPA important hydrological problems result in a reduced efficiency of the mining process. at the same time the safety of the mine operation is influenced. In the LCM the magnitude of the hydrological problems is rather small compared to the LCPA.

1.2.2.1 Hydrological Investigations in the LCPA

the following sections deal with the ground and surface water problems in the different mines of the LCPA as they are known at this time or as they are likely to develop during the next decade.

Ground water flow has already caused slope stability problems in the north Field Mine and on expit dumps. Handling of ground water has or will become an integral part of the mining process in the Amyntaion Mine.

Intelligent solutions for evolving surface water problems will contribute to efficiency and safety of mine operations.

It is RE s impression, that PPC management on the levels of LCPA and individual mines have not yet fully accepted the fact of mine water management being an essential part of the whole mining process. To rectify this unsatisfactory situation, PPC s top management is advised, to delegate to the now understaffed Geotechnical Department more responsibility and power than it has had so far. As a second step mine water management units must be established at each LCPA mine. Staffing requirements have already been dealt with in the final report of the Thalis Symphonia Project.

1.2.2.1.1 Ground Water Investigations

In the LCPA ground water problems are observed in the Amyntaion Mine, in the South Field, in the North Field and in Sector 6 & West Field South - Mines.

1.2.2.1.1.1 Amyntaion Mine Area

In the Amyntaion Mine the status of dewatering in the overburden and the pressurised aquifer in the karstic footwall of the mine present ground water problems

1.2.2.1.1.4 Ptolemais: Sector 6 & West Field South Mine

The hydrogeologic situation is comparable to that of South Field Mine. Simulation runs of a numerical ground water model, developed by DAO hydrogeologic staff predict an increase in ground water discharge, necessary for mine dewatering, as follows:

1994 - 1995	$Q = 1200\ m^3/h$
1996 - 1997	$Q = 1700\ m^3/h$
1998 - 2003	$Q = 2400\ m^3/h$

Here again, the actual shortage of submersible motor pumps has affected the progress of dewatering.

1.2.2.1.1.5 Other Mines of LCPA

At the time of writing, no other ground water problems of more than local importance have been known to exist. But given the hydrogeologically rather complex composition of the unconsolidated fill of the Florina-Ptolemais Basin, events like the unexpected appearance of a local aquifer cannot be excluded in the future.

1.2.2.1.2 Surface Water Problems in the Mines of LCPA

The overall planning figures of the PPC Technical Mine Master Plan terminate mining in the five mines of the lignite district as follows:

Northfield Mine:	Year 2003
West Field M., North:	Year 2032
Sector 6/West Field M., South:	Year 2047
South Field Mine :	Year 2034
Amyndeon Mine:	Year 2037

All these mines will leave behind remnant holes which will become prominent landmarks. Present planning features them as future lakes in a postmining landscape which indeed would be a very attractive solution to the reclamation problem. But principal difficulties exist which may threaten the whole reclamation project. They are related to the climatic and hydrologic conditions in this part of Greece and are dealt with in more details in the following sections of this report.

1.2.2.1.2.1 Surface Water Control on Inside and outside Dumps

To safely discharge the runoff from rainfall and snowmelt a system of drains and culverts must be designed which will be connected to remnant lakes or to the relocated Soulou creek. Such a system can only be designed after rainfall and runoff patterns have become established during the proposed investigation phase.

Another item of concern is the siting of Kardia and South Field outside Dumps along the toe of the Vermion Mountains without provision of discharge channels to safely divert runoff from catastrophic rainfalls to lakes or creeks. Some narrow canyon or arroyo type valleys, which apparently discharge such storm water, have simply been cut off by the eastern dump face without any provision to retain and divert the water. Design of hydraulic structures to cope with the problem will also be possible as soon as the principal rainfall-runoff characteristics have been established.

1.2.2.1.2.2 Is there a Danger of Acid Mine Drainage ?

A deplorable side effect of coal mining is very often the production of acid mine water. Iron disulphides, i. e. pyrite and markasite, are associated with coal seams and their surrounding beds. As long as the deposits remain intact, these minerals remain stable. If, during excavation, transport, and dumping, they are exposed to air and water, they rapidly react, ultimately forming sulphate (SO_4 ions), ferric iron precipitate (Fe-III), and acidity (H^+). The principal reactions of the oxidation and hydrolysis process can be summarised by a series of chemical reactions:

1. $FeS_2 + 3\frac{1}{2}O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + 2H^+$
2. $Fe^{2+} + 3H_2O \rightarrow Fe(OH)_3 \downarrow + 3H^+$
3. $Fe^{2+} + \frac{1}{4}O_2 + H^+ \rightarrow Fe^{3+} + \frac{1}{2}H_2O$
4. $FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$

As soon as the oxidation process has started, the chain of reactions 1. through 4. is maintained as long as there is still FeS_2 available. The whole process may be accelerated by the presence of the bacterium *Thiobacillus ferrooxidans*, which draws the energy for its metabolism from the oxidation process. As all reactions go on at the same time, there is a continuous production of the undesirable three chemical compounds which heavily contaminate water, rendering it unfit for aquatic life and any consumption.

"Acid mine leaching" has very often been a late-time by-product of coal mining, e. g. locally also in the Rhenish Mining District. Fortunately for PPC, it is not a problem that must be expected in the Ptolemais Mining District. There are two reasons justifying such a statement:

Even there where pyrite bearing waste rock has been exposed to air and water, triggering the start of he chain of reactions, it will be buried after dumping again by mostly cohesive, that is also impermeable waste, which limit the access of both water and air to the decaying minerals. If no air, i. e. oxygen, and water is available any more, the reaction process will come to an end. Carbonates in the waste rock will furthermore buffer, even neutralise, any eventually remaining acidity. Furthermore, due to the very low hydraulic conductivity of the dumped waste material, the rate of transport of potential water contaminants out of the inside dumps will be so low that it can for all practical reasons be considered negligible.

It is thus safe to conclude that acid mine leaching will not become an environmental problem in the post-mining period.

1.2.2.1.2.3 Rainfall Evaporation - Runoff - Relationship

The overall hydrologic budget of a given watershed is expressed by a simple equation

$$P = R + E$$

where

P= precipitation, R = runoff, and E = evaporation, all data usually expressed in mm per year.

Runoff occurs partly as surface runoff, partly, after infiltration into permeable underground, as ground water. The term watershed is applied to an area, which is bounded by a so-called waterdivide. The surface runoff portion of rain falling within this watershed, ends up in a stream or river, leaving this watershed at its lower end. Rain falling beyond the boundary of this particular watershed contributes to the runoff of another watershed. In karstic mountains as they occur around the mines of LCPA surface water and ground water divides are often different from each other. This implies that ground water catchment areas and surface watersheds are not principally related to each other.

Hydrologically, the LCPA mining district is not limited to just the Soulou Stream Valley with the extension of the Amyntaion mining field. Rather it is bounded by the water divide along the crest of the Vermion Mountains to the east, the Askion and Vernon Mountains to the west, the Klidion Horst to the north, and the Florina Ridge to the south. For this whole area, PPC conducted already in 1979 a "Hydrologic Study on the Lake Vegoritis Watershed". The whole watershed was subdivided in several watersheds and characterised by so-called run-off coefficients, i.e. percentages of measured surface runoff from recorded rainfalls. Figures show the LCPA watershed and its division in several sub-watersheds. Areas and average runoff coefficients of these watersheds are given below:

Name of sub-watershed	Area in km^2	Runoff coefficient
Lake Zazari	95	0.18 (new figure: 0.23)
Lake Chimaditis	32	0.44
Voras West	155	0.18
Ptolemais	248	0.12
Kozani West	97	not determined
South Field	516	not det,. (new figure: 0.12)
Vermion Northwest	220	0.12
Lake Vegoritis	428	0.25
Lake Petron	133	0.22
Amyntaion	96	0.15 (lowlands: 0.11)

These figures clearly show that on the average just between 10 and 20 percent of the rainfall end up as stream flow. The remainder evaporates directly or recharges the karstic or other aquifers.

As mentioned earlier, five remnant holes will become available for forming lakes, four of them being located in the Ptolemais area of the Soulou Creek Valley. Given the hydrogeologic conditions of the basin fill sediments and waste inside dumps, it is justified to say that even after recovery of the ground water in both types of material, the natural inflow of ground water into the voids will be negiblibly small. That is to say, an initial water supply to fill the lakes must most likely come from another source with exception of Amyntaion Mine.

Another question is whether or not the remnant holes will be environmentally stable, i. e. whether they can survive under the climatic conditions of the LCPA watershed. To this end, RE endeavoured to compute the annual rate of evaporation from a lake surface in the Ptolemais Area, making use of the well-known PENMAN-Formula. Basis of this computation were monthly rainfall data and humidity data for the time period 1975 -1987 of the Ptolemais Station of the National Weather Service, data of the actual daily sunshine durations for the time period 1980 - 1987 of the Kalliniki Weather Station near Florina, and only three years observation of wind speeds at Lakkia Station north of Ptolemais. Admittedly the combination of data from three different station resulted in a somewhat conservative determination of the annual evaporation rate of E = 1332 mm from a lake surface in the Ptolemais Area [ATT 14 - 3].

Papakonstantinou (1979) determined an evaporation rate from Lake Vegoritis of about 1070 mm per year, and Dimitrakopoulos, PPC, rates around 900 mm per year for years with higher precipitation.

So it appears safe to conclude that on average a layer of water of 1000 - 1100 mm thickness will annually disappear from a lake that has to be made up by an appropriated recharge, shall the lake survive.

1.2.2.1.2.4 Long-term Stability of Remnant Lakes

Depending on the altitude of the water level of a man made lake in the remnant holes , an evaporation of several million m³ per year would have to be balanced by a recharge of water from external sources as shown in the table below:

Remnant Hole	Lake Level (m a.m.s.l.)	Lake Volume [M m^3]	Lake Surface [km^2]	Evaporation [M m^3 / a]
Northfield	625	33.5	2.0	2.0
West Field	620	89.2	3.7	3.7
South Field	(640) 600	(1080.4) 633.8	(10.4) 7.5	(10.4) 7.5
Sector 6	(640) 600	(636.3) 282.1	(8.5) 5.9	(8.5) 5.9
Amyntaion	(580) 550	(650.5) 365	(8.5) 6.7	((8.5) 6.7
Lakkia	600	72.3	2.4	2.4

Both lake volumes and lake surfaces show the magnitude of the problem. In the context of this chapter, only the first four mines, remnant holes respectively, really matter. Lake levels and the resulting lake volumes have tentatively been determined. The figures in brackets for

South Field, Sector 6, (and Amyntaion) are based on approximate ground water levels in the respective upper aquifers prior to mining. But the corresponding lake volumes, lake surfaces, and annual evaporation rates reflect orders of magnitude which certainly are unrealistic, given the hydrologic and meteorologic conditions of the lignite district. Therefore, the subsequent set of figures is considered to form the base for hydrological investigations that PPC is required to carry out during the coming years (see Section 1.2.2.3.). The remnant holes of Amyntaion and Lakkia Mines will be in direct hydraulic contact to very permeable aquifers.

The deeper the lake level , the smaller its surface and thus also the smaller the annual evaporation loss. Several conclusions can be drawn from this relationship. For the time being, it is not possible to say, if there will be enough water available to make up the evaporation losses from the planned four remnant lakes, as they are supposed to exist in the fifties of the next century in the Ptolemais Area. A simple calculation indicates, however, that sufficient water for the first of these four remnant lakes in the final void of the North Field will be available.:

For the layout of the Soulou relocation an average flow rate of

$0{,}5 - 1{,}0\ [m^3 / s]$

was assumed. For this calculation a lower limit of

$0{,}5\ [m^3 / s]$.

was set. This results to a yearly runoff rate of

$0{,}5\ [m^3 / s] \times 365\ [d/a] \times 24\ [h/d] \times 60\ [m/h] \times 60\ [s/m] / 1000000 = 16\ [Mm^3 / a]$.

This volume of water is in any case sufficient, to balance the seepage and evaporation losses of the North Field remnant lake.

For the other remnant lakes in the Ptolemais area, the future investigations, described below are to be carried out in any case.

1.2.2.1.2.5 Sources of Water to fill the Lakes

such investigations must aim at obtaining the hydrological, technical, and economical data of different scenarios, how to supply Water for initially filling the remnant lakes.

Possible scenaria will include the provision of water from the Aliakmon Reservoir, certainly the most expensive solution, the provision of water from dewatering operations at the Amyntaion Mine, from the Florina Mines , but also the diversion of water from the Perdikkas Stream, or a combination of several possibilities.

No technically and economically justified recommendation on how to proceed can be given at this time. But it is believed that it will be rather easy to supply the water to the future Northfield Lake. Allowing for some seepage and evaporation losses, approximately 45 -50 million m^3 will become necessary from year 2003 onward. This water could be supplied from the Perdikkas Reservoir during winter and spring times. A pipeline of approximately 12 km length would connect the reservoir with this remnant hole. A mobile pumping station to overcome geodetic and friction heads will be necessary. But both the capacity of this pumping station and the layout of the pipeline can be designed only after a thorough study of the hydrologic budget of the Perdikkas watershed. Availability of such a budget will allow to determine both pumping rates and the time required to fill the lakes.

Filling three large volume lakes in the Ptolemais area will become a critical item in PPC´s list of responsibilities.

PPC is strongly advised to have such investigations beginning in near future, in 1996 at the latest. Apart from technical and economical implications which will affect the cost of lignite production, these investigations will give necessary information on the long-term environmental impact of lignite mining as well as possible remedy work in the LCPA area. Like any lignite mining company abroad, PPC is very likely to come under pressure by environmentalists and political parties. An environmental concept of the post-mining landscape, backed by data which have been provided by a neutral institution such as a university, will thus be of benefit to the company.

Conversion of the remnant hole of Amyntaion Mine is judged now as comparatively simple. Due to the availability of ground water around the mine, it will be possible to have this mine eventually filled with ground water. To maintain a geotechnically safe gradient from the developing lake towards the gradually recovering aquifer, the technology may involve the operations of well galleries outside the mine which will discharge the water into the remnant hole even several years after the end of lignite extraction. Numerical ground water modelling will be a suitable tool, to simulate the procedure.

1.2.2.1.2.6 Relocation of Soulou Creek

The existence of a river in an intermontane basin like the Ptolemais Basin reflects a hydrologic equilibrium between recharge and discharge.

The river discharges surplus ground water, the so-called base flow, i. e. water that cannot be handled by aquifers, and rain water that has not evaporated or consumed by plants. This equilibrium is dynamic. Recharge and discharge are not permanently equal to each other. During occasional thunderstorms in summer or during sudden snow melts in late winter the recharge may temporarily exceed the discharge capacities. Then floodings of low-lying lands along the river may occur. The equilibrium concept must thus be seen in the long term.

A small river like the Soulou creek reveals the fact that there is only a small, but nevertheless important rate of surplus water available that finally reaches Lake Vegoritis. The different input and output parameters of the hydrologic system of the basin, existing before the begin of industrialisation and modernisation of agriculture are apparently not known. Papakonstantinou (1979) reports in his paper that mining and power generating facilities, other industry, agriculture, and waste water discharge have completely altered the previously existing equilibrium. He further states that no reliable recharge and discharge figures are available. Runoff records of the Soulou Stream describe only the situation between the village of Filotas and Lake Vegoritis. They are not applicable to the situation of the area upstream of the town of Ptolemais.

A long-term planning process for the mining area, covering the remaining lifetimes of mines and power plants and the postmining time, must thus also incorporate a permanent river bed and a flood plain for the Soulou Stream by taking into account the hydrologic conditions. Omitting a new river bed from inside dump planning would result in lands becoming water clogged and a new stream developing on its own. To prevent such an uncontrolled development in the next century, dump planning must also include the relocation of the Soulou creek.

Despite the lack of confirmed input and output data to determine the water budget of the basin, RE has endeavoured to design the relocated river bed for a permanent discharge between 0.5 and 1.0 m^3/s and the adjacent flood plain for a storm water runoff in the order of magnitude of 15 to 10 m^3/s. It is believed that these figures will be more or less good approximations of reality. But it is strongly recommended to have the hydrologic investigations proposed in section 1.2.2.1.3. of this report also to the basin, in order to allow a further refinement of the design.

Attachment [ATT 14 - 4] shows the locations of inside and outside dumps, the remnant holes, lakes , and the course of the relocated Soulou creek, mostly running across dumped ground. The map shows long stretches of the stream running unnaturally straight. In reality, the ultimate stream design will include environmental desirable details such as meanders etc. The following table lists the topographic features which have served as basis of the preliminary design of riverbed and flood plain of the stream.

Approx. Length of Stream Segment (m)	Streambed Elevat. (m a. m s. l.)	Drop of Streambed (m)	Hydraulic Gradient (Fraction)
1700	652.0 - 649.5	2.5	0.0015
1400	649.5 - 647.4	2.1	0.0015
1680	647.4 - 644.4	3.0	0.0018
1100	644.4 - 639.5	5.0	0.0045
900 300 400 800	639.5 - 630.5	9.0	0.0038

According to this table, the total length of the relocated streambed is 8280 m. The length will increase upon completion of the streambed, taking into account bends or meanders that will be included in the final design. Now, however, 4800 m of upstream segments show a relatively flat gradient of 0.0015 - 0.0018, whereas the 3500 m downstream segments show a notably steeper gradient of 0.0038 - 0.0045. (Note that the river bed is at an elevation, which may be several meters deeper than the surface contour lines on the map).

The Soulou creek starts in a formerly swampy area just upstream of South Field Mine, which has been drained over the last decades. This implies that the base flow of the creek, i. e., the contribution of ground water from shallow aquifers to it, has declined. A further decline in base flow has occurred due to dewatering operations at the South Field Mine. The present creek thus discharges primarily surface runoff. But planning must provide for the postmining time, that means for the second half of the next century when there will be some base flow contribution to stream flow from the reclaimed inside dumps.

The sequence of mining operations require that Soulou creek is relocated at a time, when the inside dumps of South Field and Sector 6 Mines will have not been completed. Stream bed and flood plain will thus be created on a dam, that is to prevail as long as the inside dumps link up. In designing the height of this temporary dam, it is mandatory to incorporate the probable amount of post dumping settlement. Depending on the thickness of the inside dump, and the mode of dumping, the order of magnitude of settlement will vary between about 2.0 and 3.5 % of the thickness of the dump depending on lithologic composition of the waste. As a rule of thumb it can be stated that the settlement is below 3 % if cohesive material does not exceed 50 % of the waste. Experience in the Rhenish Lignite District is that 90 % of the settlements take place in the first three years after deposition.

Streambed, flood plain and levees will be dumped by regular action of the spreaders. Different settlements are likely to occur. In the streambed, they can be beneficial by creating ecologically desirable zones of different flow velocities. Dozing and surface levelling in other areas can remove unwanted bumps and depressions.

RE used a standard approach in designing stream bed and flood plain.
The discharge rate is a function of cross sectional area and average flow velocity.

$$Q = v \cdot A$$

This function is known as continuity equation where

Q = rate of discharge [m^3/s]

v = average flow velocity [m/s]

A = cross sectional area [m^2].

Small streams have a more or less trapezoidal cross-sectional area.

$$A = D \cdot (B + W)/\ 2$$

where

D = depth of stream (height of water level above bottom)

B = width of stream bottom

W = upper width of stream.

Flow velocity has been determined, using the empirical Manning-Strickler Formula for channel flow:

$$v = k_s \cdot R_{hy}^{2/3} \cdot I^{1/2}$$

or

$$v = k_s \cdot \sqrt[3]{R_{hy}^2} \times \sqrt{I}$$

where

k_s = coefficient of roughness of flow channel, about 25

R_{hy} =A/U = cross sectional area/wetted perimeter = hydraulic radius.

To discharge water safely without any damage to earthen stream beds and levees, flow velocity shall not exceed 1 m/s.

To develop first ideas on the design of streambed and flood plain of the relocated Soulou Stream, the following hydraulic computations were carried out, assuming a trapezoidal stream bed with

B= 1m and D = 0.5 m, slope of banks = 1/Z = 1/3.

W= B+(2D·Z) = 1+(2·0.5·3) = 4 [m]

A = D.(B+W)/2 = =.5(1+4)/2 = 1.25 [m^2]

$$U = B + 2\sqrt{1+Z}^2 = 1 + 2 \cdot 0.5\sqrt{1+9} = 4.16$$

$$R_{hy} = \frac{A}{U} = \frac{1.25}{4.16} = 0.30 \text{ [m]}$$

A comparison of these design parameters with the already completed sections of the relocated Soulou Stream of 1700 and 1400 m length clearly reveals that these sections have been over designed with respect to base flow runoff (it is shown further below that they are also over designed with respect to flood runoff).

Assuming an average gradient of 0.004 of the stream bed on the inside dump still to be created (selected from the values of 0.0045 and 0.0038 of the table above), the critical flow velocity is

$$v = 25 \cdot \sqrt[3]{0.30^2} \cdot \sqrt{0.004} = 0.71 \text{ [m /s]}$$

The respective base flow rate, which can safely handled without a destructive erosion of the stream bed is

$$Q = 0.71 \cdot 1.25 = 0.88 \text{ [m}^3\text{ / s]}$$

That means, that this design of the perennial stream bed reflects the proper order of magnitude, provided the assumed base flow rate is correct.

A comparable approach has been pursued in designing a flood plain between levees on each side that will be sufficient to safely discharge floods of an assumed flow rate Q of 20 [m^3/s] after heavy summer rains or sudden snow melts.

Assumptions are that the flood plain of the relocated Soulou Stream will be 20 [m] wide (with the permanently wetted stream bed in its centre), that it will be bound on each side by a levee of 0.80 m wetted height and 0.20 freebord and that both levees shall be sloped at 1:3.

Therefore,

$$W = B + 2 \cdot D \cdot Z = 20 + 2 \cdot 0.8 \cdot 3 = 24.8 \text{ [m]}$$

$$A = D \cdot (B + W) / 2 = 0.8 \cdot (20 + 24.8) / 2 = 17.92 \text{ .[m}^2\text{]}$$

$$U = B + 2D \cdot \sqrt{1+Z^2} = 20 + 1.6 \cdot \sqrt{10} = 25.6 \text{ [m]}$$

$$R_{hy} = A / U = 17.92 / 25.06 = 0.72 \text{ [m]}$$

The effective velocity is thus

$$v = 25 \cdot \sqrt[3]{0.72^2} \cdot \sqrt{0.004} = 1.27 \text{ [m/s]}$$

and the permissible rate of flow then amounts to

$Q = 17.92 \cdot 1.27 = 22.76$ [m³ / s]

This basic design procedure must only be seen as first step of proper hydraulic engineering. It has been based on assumptions which still need be confirmed by field observations on rainfall patterns and discharge measurements to be carried out during the next five years. In fact, these investigations have to be seen as part of the comprehensive hydrological study of the whole Ptolemais-Amyntaion Basin. They, too, should be conducted by an appropriate team of a technical university.

The new course of the Soulou creek had to be designed without providing for direct hydraulic connections to the proposed remnant lakes. The stream level will always be above the water levels of the gradually developing remnant lakes. Nevertheless it is advisable to provide some diversion channels, connecting the stream with South field, Sector 6, and Westfield Lakes to divert flood water into these lakes. Three such diversion channels are indicated on attachment [ATT 14 - 4]. The design of these channels will be similar to the flood plain design. There where they enter the mines, concrete chutes will be appropriate to prevent erosional damages to the slopes of the holes above the water level.

Operational experiences made in the Rhenish Lignite District prove that streambed, flood plain, and levees of the new Soulou Stream can be prepared directly by the spreader. Only minor compaction work for streambed and flood plain will normally required, making use of auxiliary equipment.

1.2.2.1.3 Future Investigations in the Field of Hydrology

The problems related to ground and surface water, described above, call for investigations in the future, which are to be dealt with below.

Position of the lake levels:

1. The position of the lake levels, thus also the future volume of water must be determined as a function of the available annual recharge rate that can be supplied to the lake without any incurring costs.
2. Very probably the lake level will be considerably deeper than the rim of the remnant hole. This ultimately chosen water level will be decisive in designing the slope angles of the remnant hole: A very flat angle in the zone of wave action and water level fluctuation, and a steeper angle below and above this area according to attachment [ATT 14 - 5 & 6] has been suggested by RE s geotechnical expert. As seepage is expected to occur above the highest lake level, it may become advisable to design an

extra bench with a top layer of broken rock as a drainage blanket in the slope above the water. An additional measure of safety may be achieved by planting shrubs and other plants with a high rate of water consumption and strong root systems in the zone of slope seepage.

3. Whereas it is necessary to relocate the Soulou Stream across the chain of inpit dumps between South Field and Northfield Mines as they will gradually be completed by the year 2015, it will apparently not be possible to have the stream course hydraulically connected to the remnant lakes. Soulou Stream is therefore unlikely to become a stream gaining some discharge from the lakes. The stream will thus flow on a higher level than the lake levels. It is advisable, however, to provide some flood beds between the stream and some of the lakes which will allow to safely discharge flood water from catastrophic rainfalls from the stream to the lakes.

The water Balance in the Ptolemais / Amyntaion Area:

At present, the data base necessary to calculate the annually available rate of water in the LCPA watershed does not exist. The basis, PPC's study of 1979 on sub-watersheds and their respective average or long-term runoff coefficients marks just the beginning of a se-veral year field investigations and practice-oriented evaluation. In RE's opinion, such a study would consist of, but not be necessarily be limited to, these working steps:

1. Set up at different altitudes in the mountains on both sides of the Soulou Stream Valley some automatic rainfall recording stations which monitor not only daily totals but also 12 h, 6h, 3h, 1h, 30 min and 10 min rainfall events.
2. Establish within the already established sub-watersheds even smaller watersheds which appear to reflect local runoff characteristics as affected by the geologic underground. It can be expected that runoff coefficients of geological diverse sub-watersheds vary distinctively more than the average coefficients of the rather large sub-watersheds.
3. Establish for the small sub-watersheds not only the long-time runoff coefficients, but also short-time peak runoff coefficients for short-time events like heavy summer thunder-storms and sudden snow melts.
4. Establish within the course of about five years field work rainfall and runoff patterns in the sub-watersheds for probability analyses, the so-called rainfall intensity -duration cur-ves for different return periods.
5. Determine the rates of runoff water generated in the sub-watersheds and which may theoretically be available to recharge one or more of the remnant lakes. It is understood that only surplus water will be available for recharge as the flow in the perennial streams,which spring from the mountains, has already been allocated for local agricul-ture.

6. Determine by geological mapping where there are appropriate sites in the mountains to tap peak runoffs before the water can infiltrate into permeable karstic rock complexes as it is the case now. Appropriate sites are depressions within impermeable rock units such as flysch, magmatic rocks, serpentinites that crop out in western Vermion Mountains.
7. Design contoured concrete channels to divert the tapped water by gravity towards the lakes (such channels have already been built by orchard owners to irrigate their fruit trees).
8. Check other possibilities of an annual water supply to make up the evaporation losses, e. g., an annual transfer of water from the Perdikkas Stream.

Such a complex study will require about five years of field and successive computerised evaluation work. In RE's opinion, it should be carried out by a team of hydrogeologists of a technical university in close co-operation with PPC, IGME, and the National Meteorological Service.

1.2.2.2 Hydrological Investigations in the LCM

Given the remaining lifetimes of the openpit mines of the Megalopolis Mining District, the magnitude of mine water problems is rather small if compared with that of LCPA. Nevertheless, some technical details deserve attention which are dealt with in the following sections.

Kiparissia Mine

Kiparissia Mine is the only mine of LCM which requires the withdrawal of ground water from a footwall aquifer. A karstic limestone aquifer in the deeper footwall with a head of initially 340 m a.m.s.l. is separated from the lignite seam by about 60 m thick impermeable clayey sediments. Only in the western part of the mine does a cliff-like outcrop of the limestone penetrate the otherwise intact impermeable footwall strata.

PPC has drilled and operated depressurizing wells which are screened in the limestone aquifer. These wells have lowered the potentiometric surface of this aquifer to a level of now 295 m a.m.s.l. Total well discharge amounts to about 2500 m^3/h. Drawdown and rate of discharge are sufficient to safely operate the mine and supply the power plants with water.

As excavations in the mine will eventually reach a level of 270 m a.m.s.l., more wells are being sunk. There is no doubt that this dewatering target will be reached in time.

1.2.3 Geotechnical Investigations

Especially in the deeper mines (South Field, Amyntaion) the masscalculation results can depend strongly on the inclination of the slopes. This applies to the mining ratio as well.The inclination of the perimeter slope, of the excavation face and especially of the system of dump slopes influence the size of the mine opening. The size of the mine opening in the critical mine position results to the demand of expit dumping volume. Last , but not least the geotechnical assumptions for the permanent slopes in the final void of the mine can have an essential influence on the masscalculation results. Hence the importance of the geotechnical investigations for the accuracy of the basic mine design must not be underestimated.

In this report, geotechnical investigations are stability investigations of opencast mine slopes. The object of these stability investigations is to develop and define slope geometries ensuring sufficient stability at maximum deposit exploitation. Moreover, the stabilities of final slopes in outside dumps and -in the case of opencast mine final voids- in inside dumps are to be investigated. On the basis of these tasks, the following will be a description of which geotechnical investigations are required in the opencast lignite mines of the Megalopolis, Ptolemais and Amyntaion mining areas.

In order to prepare this description of the investigations, the author of this part of the report, Dipl.-Ing. Pierschke, made the following inspections and had the following discussions:

1. Inspection of PPC's lignite mining areas in the period from 03 to 12 November 1993. Report dated 09 February 1994 *[SCT 7.3 - 2 - 0]* .
2. Discussions on the occasion of the geotechnical seminary held at Ptolemais from 26 June to 02 July 1994. The large scale test proposed at that time to determine the limit heights of the dump material (proposal submitted by the Geomechanical Department on 27 April 1994) could not be implemented on the outside dump of the South Field opencast mine for mine-specific reasons *[SCT 7.3 - 3 -0]* .
3. Discussions dealing with geomechanical problems held during a visit of Mr. Marios Leonardos (PPC) visit to Rheinbraun's Geomechanical Department in the period from 31 January to 11 February 1994.
4. Development and definition of a geomechanical investigation programme in joint co-operation between Mr. Leonardos (PPC), Mr. Herbst (RE, PPC Masterplan Team) and Mr. Pierschke (Rheinbraun Engineering) in the period from 03 to 06 April 1995.

1.2.3.1 General Procedures for Stability Investigations

The stability investigations of opencast mine slopes consist of the following steps:

- geological investigations
- hydrological investigations
- geomechanical investigations
- stability calculations
- slope monitoring

1.2.3.1.1 Geological Investigations

The geological investigations are necessary to determine the deposit parameters which influence the stability of the slopes and have to be considered in the subsequent stability calculation and assessment. The following are the geological parameters having an impact on the stability of the slopes:

- Interbedding of various soil strata and lignite seams characterised by different shear strength parameters.
- Dipping of strata which -depending on the slopes' locations- reduces the stability; for example, strata dipping in the same direction as the slope inclination.
- Weak zones in cohesive soils which result from sedimentation and are characterised by extremely low shear strengths.
- Weak zones which result from tectonics such as faults. The dipping of such faults has the same reducing effect on stability as the dipping of strata. Moreover, the shear strength in the fault zone is reduced by the tectonic fracturing processes.

The geological conditions and the investigations still to be performed (e.g. exploratory drillings) are described in *[SCT 1.2.1]* of this report. Geological investigations for geotechnical purposes are result in maps and sections, with the latter being used for calculations of the slope stability.

To assess the influence the geological parameters have on an **opencast** mine rim slope, it is necessary, for example, to prepare sections spaced 200 m apart. For complex geological conditions, which can be recognised by differences in the individual sections, stability calculations have to be performed in each section in the most unfavourable case. In extremely irregular parts of deposits, in particular those subjected to substantial tectonic stresses, even smaller distances between the individual sections have to be selected.

Regarding the stability of **dump slopes,** the geological sections through the deposit reflect the composition of the dump material, for example the portion of the cohesive, stability-reducing material. In addition, the geology of the dump base in the opencast mine floor and/or on the surface level has to be illustrated in geological sections going down to depths of 30 m below the base of the dump.

1.2.3.1.2 Hydrological Investigations

The hydrological investigations *[SCT 1.2.2]* have to be performed to calculate and assess the influence of the ground water on the stability of slopes. Aside of the well known effects of water on the stability of slopes in original material, undisturbed by excavation and transportation, there are strong impacts of water on the stability of dump slopes. The strength parameters of dump material are reduced considerably. if the groundwater in the mine has not been sufficiently drained or if the surface dewatering measures are not appropriate.

1.2.3.1.3 Geomechanical Investigations

Geomechanical investigations serve to determine the soil characteristics and parameters which are needed to assess and calculate the stability of opencast mine slopes. The main parameters are the shear strengths which are determined according to different procedures and methods.

In the **laboratory,** the shear strengths are determined in so called direct shear tests and ring shear tests. For the investigations necessary here the ring shear tests are of minor importance and necessary only to determine the residual shear strengths; the latter can, however, also be determined in direct shear tests according to the direct shear test (Vienna system).

The test installations required to perform direct shear tests and triaxial shear tests are available in PPC's geomechanical laboratory. However, this equipment will have to be modified or supplemented to reach the stress levels that will result from the future opencast mine depths. In this context, we refer to the Inspection Report *[SCT 7.3 - 2 - 0]*. According to Mr. Leonardos, the required supplement is planned to be made in the laboratory but has not yet been implemented.

Another form of determining shear strengths is the **back analysis** of slope failures and slope movements if the location of the slip plane is known. This method is applied by PPC.

Special **in situ tests** to determine the undrained shear strength of cohesive dump materials are the vain shear tests. However, it is above all the dumping tests to determine the limit height as described in *[SCT 7.3 - 3 - 0]* which provide appropriate information on the strength behaviour of dump material.

1.2.3.1.4 Stability Calculations

The stability calculations are made on the basis of the results obtained by the investigations described so far. The calculation methods applied are the so called slice methods, for example Bishop, Janbu, Bureau of Reclamation, as they are used both at PPC and Rheinbraun. These methods usually apply to circular slip planes only and are not correct mechanically for combinations of rectilinear slip plane sections. For such slip planes, for example of straight line combinations, the block method according to *Gudehus* which is mechanically correct is to be applied. This method is partly applied by PPC as well.

A third method, the so-called spatial calculation method is used at Rheinbraun to demonstrate both the supporting effect backfilling has on the opencast mine rim slope and the resulting increment in stability.

The result of the stability calculation is the so called factor of safety η. Whether the factor of safety determined by calculation is satisfactory will depend on the following criteria:

- The safety of persons inside and outside the opencast mine must be ensured.
- Safety of objects inside and outside the opencast mine, for example buildings, opencast mine equipment, inter alia.
- The substance and reliability of the geological, hydrological and geomechanical investigation results.
- Technical possibilities of slope stabilisation in an operating opencast mine.
- Life and use of the slope, for example final void or outside dump, where permanent stability is required.

In accordance with the guidelines of the German Mining Authority and with account taken of the mentioned assessment criteria the calculated stability of a slope shall as a rule be

η=1.3

1.2.3.1.5 Dump Stability Investigations

The construction of stable dumps requires geological, hydrological and geotecnical investigations combined with operational measures corresponding to the findings of these investigations.

Two critical areas are to be mentione din this context

- The selective excavation and dumping of stable an unstable dump material and
- the problem of pore water pressures.

1.2.3.1.5.1 Selective Ecavation & Dumping of Dump Materials

The aforementioned gelogical, hydrological and geotechnical investigations result in a classification of the waste material for the construction of dumps.

Soil material with an appropriate grain distribution curve -less than 30 % clay and silt- in the which is sufficiently consolidated *[ATT 14 - 7]* is suitable for the construction of bunds and bench surfaces. All other dump material must be retained behind the aforementioned bunds *[ATT 14 - 8]*.

The height of the bunds is to be kept below the so called height limit *[ATT 14 - 9]*. The lower part of dump slopes starts to flatten, as soon as a certain height is exceeded. This effect is the consequence of the fact, that two different sets of strength parameters can be assumed for the dump material *[ATT 14 - 10]*.

The first set is representing the strength of the grain skeleton formed by the lumps of cohesive material which normally form the dump material. This is the strength of a granular soil material where the grains are so called secondary grains (High angle of internal friction φ_1, no cohesion).

the second set is representing the strength of the aforementioned „secondary grains" of cohesive soil material (Low angle of internal friction φ_2, high cohesion c_2).

At low normal stresses which depend on the height of the dump the strength of the grain skeleton is lesser than the strength of the grains. Under this conditions the slope angle of the dump is determined by the angle of internal friction in the skeleton of secondary grains φ_1. We observe a steep slope with an inclination in the order of 1 . 1,5.

After having exceeded a certain height which is typical for the dump material, the strength of the skeleton of secondary grains is, however, higher than the strength of the secondary grains itself. The slope angle of the lower part of the dump slope, where this condition is fulfilled first, is then determined by the much lower angle of internal friction of the secondary grain material φ_2. It starts to flatten considerably.

Normally we must avoid this situation carefully, because the spreader is not in the position,to dump material in front of the toe of the flat part of the slope. As a consequence a continously increasing mass of flowing soil starts to develop which is a danger for other spreaders of for the lignite excavation.

The height limit for the dump material can be roughly assessed by the application of the relations between the aforementioned two kinds of strength shown in attachment *[ATT 14 - 10]*. The better approach is, however, to carry out the aforementioned dump tests.

The selective excavation and dumping of the two types of dump material described above for the construction of the dumps as indicated in attachment *[ATT 14 - 8]* is difficult in PPC s mines, because each spreader is normally to serve more than one excavator. The necessity, to apply these measures can, however be reduced by appropriate groundwater drainage and surface dewatering measures. Hence these subjects are even more important for the stability of the dumps than for the stability of slopes in undisturbed soil material.

In a similar wayl a normal section for the final slopes is to be designed.

In both cases the fractions of stable and unstable material according to the classification of the dump material described above are to be taken into account and the design must be checked by a stability calculation. Decreasing quantities of stable dump material result in flatter slopes and vice versa.

1.2.3.1.5.2 The Influence of Pore water Pressures

The wet material in a dump especially in the backfill behind the bunds *[ATT 14 - 8]* is a problem during two periods of time during the dump operation

When this material is dumped behind the bund an increasing load is acting on it. Pore water pressure is reducing the strength of the material. The low undrained shear strength must be assumed for this material during this phase of the dump operation. The normally low permeability of the backfill results in long periods of time (not months but years) until the pore water pressures start to decrease considerably.

Whenever the next bench of the dumpis increasing the load, acting on the wet material, the pore water pressures increase correspondingly.

In this case a very flat general inclination is to be applied, to keep the system of bench slopes stable. The inevitable negative effects are then an increasing demand of expit dump volume or a reduction of the volume of expit dumps.

Appropariate drainage of the ground water and an effective surface dewatering system are again the remedy measure to be applied.

1.2 3.1.6 Slope Monitoring Methods

With the construction of the opencast mine rim slope, slope monitoring starts with the object of obtaining information on the slope's movement behaviour and the correctness of the parameters used in the stability calculation.

The slopes' movement behaviours are determined on the one hand by terrestrial measurement and on the other hand by in situ measurement methods. The terrestrial methods, such as the Georobot method applied by Rheinbraun, show the movements of the slopes' surfaces. The course of the measurement results illustrated in a displacement-time diagram reflects whether the movements are normal relief deformations or initial fracture deformations. The latter endanger the slopes' stability and usually call for stabilisation measures.

In-situ measurements, for example the inclinometer measurements in boreholes carried out at PPC, show slope deformations within the rock mass. Thus it is possible to identify not only the course of the deformations but also their locations, for example the geological horizon, in which the movements take place.

This method permits early identification of weak zones and/or slip planes in the rock so that it becomes possible to initiate measures for the stabilisation of potential fracture conditions on the basis of back analyses.

This method also permits conclusions as to the shear strength in such zones that can be used in stability calculations for the subsequent slope sections if those are comparable in terms of geological conditions.

1.2.3.2 Stability Investigations carried out in the Past

As already outlined in the Report *[SCT 7.3 - 2 - 0]*, stability investigations were performed within the scope of the planning work carried out in connection with the studies prepared by Professor Goergen and the Otto Gold company.

The stability investigations performed by PPC so far are not based on geological sections representing the stratigraphy and tectonics in such a way that the dipping of strata and faults, for example, can be clearly identified. The sections available only show the drill logs without any correlation of the strata.

The bulk densities and shear parameters necessary for the stability calculation were determined for a few strata series by triaxial and direct shear tests. A number of shear strength parameters were obtained by means of back analyses of slope movements and failures. The calculation procedure used to determine the stability is the Bishop/Janbu method.

Due to the incomplete geological representation the stability calculations are carried out as so called risk analyses in case studies. On the basis of assumptions the geological-tectonic rock structure is varied by alternate dipping and different shear parameters. As far as applicable, these case studies are then selected depending on the situation in the opencast mine. In the opencast mine rim slopes movements are surveyed in drill holes by means of inclinometers in special slope sections only. The stability is calculated and the inclinometer surveys are evaluated using PC programmes of the Mitre Software Corporation Canada that are called G TILT Plus.

1.2.3.3 Assumptions for the Inclination of the Mine Slopes at Present

On the basis of this stability investigation approach, PPC's Geotechnical Department gave the following slope geometries for the planning of the individual opencast mines in the LCPA and LCM to the Mine Masterplan Team:

1.2.3.3.1 LCPA-South Field

Rim Slope:

Depth	Type of Soil	Inclination
0 - 50 m	--	1 : 2.5
50 - 100 m	--	1 : 2.7
100 - 150	--	1 : 2.9
150 - 200	--	1 : 3.1
>200	--	1 : 3.2

Excavation Slope Systems:

Depth	Type of Soil	Inclination
< 90 m	Overburden (5 benches)	1 : 5.5
90-125 m	Lignite Series (5 benches)	1 : 4.2

Expit Dump. final Slopes:

Depth	Type of Soil	Inclination
0 - 50 m	--	1 : 3
50 - 100	--	1 : 4
100 - 130	--	1 : 4.5

Inpit Dump, Final Slope

Depth	Type of Soil	Inclination
0 - 50	--	1 : 3.5
50 - 100	--	1 : 4.5
100 - 150	--	1 : 5,0

Inpit Dump under operational Conditions

Depth	Type of Soil	Inclination
--	--	1 : 7 - 15

1.2.3.3.2 Other PPC-Mines

Rim slope:

Depth	Type of Soil	Inclination
0 - 50	--	1 : 3
50 - 100	--	1 : 3
100 - 150	--	1 : 4
150 - 200	--	1 : 3.5

Excavation slopes

Depth	Type of Soil	Inclination
60 m	Overburden (2 benches)	1 : 3.2
90 m	Overburden (3 benches)	1 : 3.9
135 m	Overburden (3 benches)	1 : 1,9
50 m	Coal	1 : 2.6
75 m	Coal	1 : 3

Expit Dump, Final Slope:

Depth	Type of Soil	Inclination
86 m	--	1 : 4.7

Inpit Dump, Final Slope:

Depth	Type of Soil	Inclination
0 - 100 m	--	1 : 5.5
100 - 150 m		1 : 6.5
150 - 200 m		1 : 7.5

Inpit Dump under operational Conditions

Depth	Type of Soil	Inclination
--	--	1 : 6 - 10

1.2.3.3.3 The Slopes of the Final Voids

For the final void slopes data provided by Rheinbraun's Rock and Soil Mechanical Department were taken as a basis instead of the figures mentoned above:

Final Slopes in the final flooded Mine Opening:

Depth	Type of Soil	Inclination
--	Undisturbed Material above the Water Level	1 : 5
--	Undisturbed material in the Zone of Wave Attack	1 : 10
--	Undisturbed Material below the Water Level	1 : 5
--	Dump Material above the Water level	1 : 7
--	Dump Material in the Zone of Wave Attack	1 : 10
--	Dump Material below the Water Level	1 : 7

[ATT 14 - 5 & 6]

1.2.3.3.4 Assumptions for the Height Limit of Dumps

The required mumber of spreader benches depends on the height limit for the individual dump slopes *[SCT 1.2.3.5.1]* .

At present we assume a heigt limit of

20 []m].

This limit applies normally to the dump slopes on the deep dump side. On the high dump side additional restrictions related to the geometry of the spreader are to be observed. A high dump slope of

20 [m]

height does correspond in any case to the maximum discharge heigt of the spreader.

The total maximum dumping height for one spreader is then eithertwo times the height limit for a single dump slope

2 × 20 [m] = 40 [m],

or a deep corresponding to the height limit of a single slope plus the maximum discharge height of the spreader.

20 [m] + maximum discarge height of the spreader < 40 [m]

In the deeper PPC mines-e. g. Amyntaion- these restrictions present a problem. The mine geometry calls for more dump benches than the number of the spreaders available.

1.2.3.4 The Future Stability Investigations

The slope inclinations indicated above, that were used as a basis for planning are to be regarded as assumptions and must **by all means** be reviewed by stability investigations according to the standards and procedures described in this report. This applies only to planned opencast mines and opencast mine sections. For already operating mines, the statements made in the above mentioned Report *[SCT 7.3 - 2 - 0]* are applicable. The necessary investigations have been comprised in *[ATT 14 - 11]*.

1.2.3.4.1 Lignite Centre Megalopolis: Khoremi

From its present position in which the three lower benches still have to be developed the opencast mine will have a life of 36 years until 2031. The average mine depth is 110 m, with the greatest depth of 140 m being reached at the eastern rim slope. The average general inclination of the opencast mine rim slopes is planned to amount to 1 : 2.5; a stability investigation -as described under *[SCT 1.2.3.1]* has not been carried out. The general inclination corresponds to the targets set by Professor Goergen's planning.

During the opencast mine's development to the present position, major stability problems arose at the eastern rim which were described in the report *[SCT 7.3 - 2 - 0]* .According to the statements made there, stability investigations must be made prior to the construction of the slope systems.

As far as the Eastern final slope is concerned, PPC (Mr. Leonardos) has performed a number of short-term investigations and has taken slope stabilisation measures. Moreover, the following investigations were proposed by RE in the above report *[SCT 7.3 - 2 - 0]* .

for the initially flatter inclination, the inclination planned now is to be reviewed by all means. Since the opencast mine is currently beginning to expose this slope section, the investigations have to start immediately.

In view of the striking slope length and the section spacing of 200 m, a total of 22 cross sections is to be prepared after completion of the exploratory drillings. The drilling programme should be carried out from Northwest to Southwest in order to obtain information on the first 1000 m of slope length in the next few months. It is for this area that the first 4 to 5 geological sections are to be prepared. Subsequently, the stability investigation is to be performed according to *[SCT 1.2.3.1]*. and as described in the TMMP-Note *[SCT 7.3 - 4 -0]*. Due to the long slope life the residual shear strengths will have to be determined as well.

This stability investigation can also be used to optimise the safety distance to the Kardia power plant. At present a safety distance of five times the slope height between the power station and the perimeter slope of the South Field is to be maintained [REF 950302HT - 2/7]. This safety distance may be reduced, only if the investigations, mentioned above, allow to do so.

1.2.3.4.5 Lignite Centre Ptolemais Amyntaion: Sector 6 & West Field-South

The Sector 6 & West Field-South opencast mine extends over a total area of approx. 14.5 km². The opencast mine's depth ranges between 80 m and 220 m. According to the RE report on geology the strata series and the respective soil types correspond to the conditions prevailing in the South Field. The faults striking WNW-ESE to NW-SE subdivide the mining field into several fault blocks.

There are two areas which are particularly important for the stability investigations: the western rim slope and the area of the final void.

The greatest depth of 220 m will be reached in the area of the western rim slope. The investigations made within the scope of the planning work started out from a general inclination of 1:3.2 in accordance with PPC's soil-mechanical targets. The Ptolemais-Kozani road and railway line are planned to be relocated at a distance of 220 m behind the opencast mine crest. Moreover, the slope system is located at the deposit's basic rim which is characterised by tectonic faults dipping in the direction of the mine. These faults are geological weak zones which have a considerable effect on the slope's stability. Extensive stability investigations are therefore required here which should be completed by the year 2020 approximately, because the transport routes will have to be relocated at that time.

According to the planned mining direction, the depth develops from 80 m to 220 m in the western final slope having a length of around 6 km. A total of 30 geological cross sections is to be prepared for the stability investigation as described in *[SCT 1.2.3.1]*.

For the **area of the final void** which will be exclusively located within the inside dump, a standard section with given material composition is to be developed with respect to the dumped final slope. The stability investigation required for this purpose will have to consider the filling-up type and phases and the wave attack zone of the residual lake. On the basis of this stability investigation the general inclination of the residual hole's rim slopes is to be defined, with permanent stability being demanded.

The safety distance between the power station Kardia and the excavation front of the west Field South is to be maintained as indicated in *[SCT 7.3 - 4 - 0]* unless the results of the stability investigations allow for a reduction.

1.2.3.4.6 Lignite Centre Ptolemais Amyntaion: West Field-North

The West Field-North opencast mine extends over an area of approx. 11 km². Its depth ranges from 40 to 170 m. In accordance with its slewing direction, the opencast mine develops from a flat part being 40 to 50 m deep at the eastern rim slope down to a 170 m deep area at the western rim slope to reach its final position in another flat area having a depth of 40 to 50 m at the north-eastern final slope. Objects to be protected in the slope rim areas are the Kozani-Ptolemais railway line and road (relocated at the time of excavation) and the Ptolemais/Liptol power plant. That is why in addition to the stability investigations with respect to the rim slopes, which are necessary for the opencast mine safety, the safety distances of the objects to be protected from the opencast mine crest planned so far will have to be reviewed as well.

According to the statements made on the geological conditions of this mining field *[SCT 1.2.1]*, the overlying rock consists of an interbedding of soils similar to the opencast mines described so far with a pronounced division into split seams in places. In addition, there are NW-SE striking faults, which has an adverse effect on the stability of the western to south-western rim slope. That is why the geological report places special emphasis on this area and the necessity of at least 9 additional drillings. This will serve mainly to determine the

1.2.4 Calculation of the Remaining Reserves

The geological, hydrological and geotechnical investigations, described in the sections *[SCT 1.2.1 - 3]* are to be taken into account as the necessary basis for the calculation of the remaining reserves in this section.

Apart from the influence of the geotechnical investigations, which depend on the results of the geological and hydrological investigations, the quality of the masscalculation results is determined by the accuracy of the mine modelling procedures, by the application of appropriate algorithms for the definition of exploitable lignite- or waste blocks or for the calculation of the average quality parameters and by the correctness of the input of quality data.

The following subjects are to be handled in this context:

1. General matters, related to the calculation of the remaining reserves
2. The remaining reserves in the LCPA
3. The remaining reserves in the LCM.

1.2.4.1 General Masscalculations Matters

The general, masscalculation related matters include areas of concern, which have been identified from the point of view of the Masterplan Team, as they resulted to inconsistent calculation results.

Such areas of concern are:

- Mine modelling procedures,
- the algorithm for the determination of blocks,
- the criteria of evaluation,
- The calculation of average block qualities,
- the algorithms for the calculation of mine model quantities and qualities.
- Others

After having changed PPC s masscalculation software as described bekow, it is suggested to prepare an appropriate the documentation for this software and to actualise it regulariy.

1.2.4.1.1 Mine Modelling Procedures

During our work improved procedures for the modelling of inclined slopes and for the modelling of bench wise quantities have been achieved.

Slope Modelling:

When we started our work, the representation of the inclined slopes of the mines in the mine model were normally vertical planes in the middle of the slope.

This substitution does not correspond precisely to the mine geometry. Any mine model is a three dimensional thing. This is the reason, why the substitution of the inclined slopes by vertical planes in the middle of the slope

- falsifies the total excavation figures slightly and
- results normally to a slightly better ratio.

Compared to the actual mine a material quantity in the upper part of the slope is missing and in the lower part of the slope another quantity is added. Because normally the lignite is concentrated in the deeper parts of the mine, and the waste is normally concentrated in the upper part of the mine, the mining ratio is falsified This has been checked and proven by a model calculation during the start up phase of the project.

A component of PPC s masscalculation software „Metal" called „PIT" has been designed as a remedy measure for this inaccuracy.For the application of „PIT" the slope inclination is defined as shown in *[ATT 14 - 12]*. The angle between the slope surface and the horizontal line outside of the mine or sector must not be more than 90°. This restricts the application of Pit to the so called classical pit, where the upper crest of the slope is always outside of the lower crest or vertically on top of it.

This does unfortunately not apply to the normal case of a sector wise masscalculation. The total mine can be calculated, but the individual sectors cannot be calculated with "PIT". It is an appropriate remedy measure not to calculate the volumes of the individual sectors but the accumulated volumes until the end of each sector. The sector volumes can then be obtained by subtraction of the accumulated figures *[ATT 14 - 13]* .

„PIT" replaces the actual slopes by triangles with two corner points on the upper crest of the slope and one corner point on the toe of the slope or vice versa. Minor problems with this algorithm have been removed. The present version of the slope modelling algorithm produces plausible models of inclined mine slopes.

During bench wise masscalculations for the two parts of the West Field major differences between the calculations with or without benches have been observed. The total excavation figures of both calculations were close to each other, whereas the the wast and lignite figures wer different by far.

The reason for this effect is the method of assigning the accumulated block thicknesses in the drill holes to the corner points of the masscalculation grid *[ATT 14 - 14]* .

Up to now the upper and the lower elevations of a bench at the corner points of the masscalculation grid have been projected horizontally to at least the next three neighbouring drill holes. The block thicknesses of lignite and waste in these drillholes between the bench elevations at each grid point are then the input for the intepolation of the thicknesses between the drillholes. As indicated in *[ATT 14 - 14]* this procedure falsifies the input for the interpolation considerably.

As we see it, it is logical, to determine the block thicknesses for waste and intercalations between the upper or lower bench elevation at the drillhole and to use these thicknesses for the interpolation between the drillholes.

By introducing this new bench modelling procedure, the accuracy of bench wise masscalculations has been improved by far.

Today we regard „PIT" as an applicable solution.

1.2.4.1.2 The Algorithm for the Determination of Blocks

If the multi layer deposits in the LCPA and in the LCM were to be exploited layer wise with a bucketwheelexcavator large areas in these deposits would not be mineable. Hence mineable „sandwiches of several lignite and waste layers are to be determined.

This activity, called compositing by geologists is an iterative process.

The criteria of evaluation are

- the minimum thickness of lignite and waste for selective mining,
- mining loss and dilution at the top and bottom of each sandwich unit or block and
- the cut off ash content.

These criteria of evaluation are the input for an algorithm, which defines the so called blocks with average quality parameters (ash content, water content calorific value, density of lignite).

The above mentioned algorithm for the definition of blocks did not result in blocks according to the criteria of evaluation in the beginning. Waste layers thinner than the minimum thickness for selective excavation were declared as mineable blocks. An adjustment of the algorithm has been designed and integrated into PPC s software package in co-operation with the Direction of Informatics, Section of Technical applications.

The present procedure for the determination of blocks might not be the final optimum approach. More favourable results may be achievable, if mining losses and dilutions are no constant parameters for each block can be varied according to the average quality and thickness of the block. There might additionally be options, to improve the general strategy of block determination.

At present a status has been achieved, where the lignite and waste blocks correspond to the criteria of evaluation, which must be sufficient for the time being.

1.2.4.1.3 The Criteria of Evaluation

The result of the block definition process is signigicantly influenced by the aforementioned criteria of evaluation.

During the preparation of the TMMP varioous sets of evaluation criteria have been discussed *[ATT 14 - 16]* . At the beginning of our work the criteria „PPC 1" were usually applied. It was our intention to introduce the criteria called „TMMP". Recently the LCPA has introduced another set of evaluation criteria called PPC 2 .

These sets of criteria have been discussed intensively since the start up of our work. A certain approximation of the different points of view but no final agreement has been achieved. In this context the following statements are essential:

- Up to now there are no accurate actual quality figures. The power stations provide the quality for their total fuel consumption only (Normally a mixture of lignite from more than one mine and other fuels as xylithe and imported black coal).
- Our counterparts in the lignite centres have not yet presented their masscalculations including the average quality parameters.
- The quality of the strata without analysis is up to now based on assumptions. These figures are, however, influencing the masscalculation results (Quantities and qualities) considerably.
- Accordingly there are little facts supporating the different points of view. There is, however, at least one calculation result, which indicates, that further reductions of the thicknesses for the deposit evaluation might not apply.

  For the West Field North, where the reserves and quality parameters have been discussed recently especially intensive, and for the North Field and Komanos, which have been the major suppliers of lignite for the Liptol and Ptolemais power stations,we have calculated the quality parameters of the „pure lignite" *[ATT 14 - 17]* .

The differences between the quality of the „pure lignite" and the actual figures or the masscalculation results is the consequence of dilutions. Additionally intercalations thinner than the minimum thickness for the selective mining of intercalations may have been added to the lignite blocks.

These differences are rather small compared to other mines we know. this indicates, that the thicknesses for the deposit evaluation are small in both cases.

PPC s proposal is, to increase the accuracy of the process of selective mining and to apply more losses than dilutions. The corresponding increment of the reserves is quite a bit. The difference of the reserves according to PPC- or TMMP-criteria decreases as the limit for the calorific value decreases and as the calorific value assumed for the strata without analysis increases.

In the following sections we try to judge the different sets of evaluation criteria based on technical considerations. We set our thicknesses for the deposit evaluation at their lower limit. We regard further reductions as proposed by our counterparts in the LCPA as not realistic.

At present the deposits have been evaluated assuming, that no „other fuels" are to be supplied to the power stations. This assumption needs to be reviewed.

Further investigations are required referring to the quality of the strata without analysis. Their influence on the results of our masscalculations is as strong as the influence of the supply of „other fuels". We can no more rely on assumptions only.

The following actions or investigations are regarded necessary in this context:

- Installation of facilities for sampling and lignite analysis in the lignite handling system of each mine (Analysis of the ash-, water-and lime-content and of the calorific value of the ash- and waterfree combustible matter in the lignite).
- Collection of an appropriate number of intercalation samples in each mine from the excavation face plus analysis of the ash-, water- and lime-content of these samples

1.2.4.1.3.1 Thicknesses for selective Mining

The minimum thicknesses of lignite and waste for selective mining are related to the type of the equipment. These parameters are to be set according to the construction of the excavators (size of the bucketwheel, height of the buckets).

The minimum thicknesses for the selective mining of lignite and intercalations have been set at

50 cm

taking into account a bucket height of about

70 cm.

It is a well known fact, that the effective capacity of a BWE is related to the height of the slice to be excavated *[ATT 14 - 15]* . As the slice height decreases the cross section of the cut and decreases. Within certain limits this can be balanced by an increasing depth of the cut. A slice height equal to the height of the bucket is normally the lower limit. We apply a slice hight, which is already below this lower limit. Further reductions cannot be accepted according to our point of view.

The minimum thicknesses for mining lignite and intercalations selectively schould be equal because both materials are to be excavated by the same wheel.

PPC new set of evaluation criteria (PPC 2) *[ATT 14 - 16]* introduces different dilution- and loss-thicknesses. The thicknesses for selective mining are influenced.

The thickness of each lignite block is reduced by the mining losses and increased by the dilutions. This results in a minimum thickness of the lignite block of

50 [cm] Lign.- 2 × 10 [cm] Lign.+ 2 × 3,5 [cm] Waste= 37 [cm] Lign.

The thickness of the intercalation block is reduced by the dilutions and increased by the losses. This resuts in a minimum thickness of

20 [cm] Waste- 2 × 3,5 [cm] Waste+ 2 × 10 [cm] Lign.= 33 [cm] Waste.

The minimum thickness of intercalations for selective mining determines the first component of the dilution of lignite. the intercalations thinner than this figure will be excavated together with the lignite layers above and below. they are „embedded" dilutions.

We suggest, not to adopt these reduced thicknesses for the selective mining of lignite and waste blocks. They should rather be increased and not reduced. A final comment freferring to the total dilutions Embedded dilutions plus „surface dilutions"*[SCT 1.2.4.1.3.2]* will be presented in section *[SCT 1.2.4.1.3.3]* .There is a possibility to judge the total dilutions based on a comparison of masscalculation reaults and actual production figures.

1.2.4.1.3.2 Mining Loss & Dilutions

Referring to the mining losses and dilutions a certain adjustment of the different points of view has been achieved. The dilutions at the top and bottom of the lignite blocks (Surface dilutions) have been discussed especially intensive, because our counterparts in the LCPA are convinced, that the thickness of the dilution as set by the Masterplan Team is the reason for a reduction of the reserves.

At the beginning of our work the thickness of the dilutions was normally set at

2 × 00 [cm]

by our counterparts in the lignite centres. Recently it has been proposed to set it at

2 × 3,5 [cm].

According to the proposal of the Masterplan Team an equal thickness of

10 [cm]

for mining losses and dilutions has been assumed

As illustrated in attachment *[ATT 14 - 18]*, it is not easy to accept, that a surface dilution dilution of

3,5 [cm]

schould be achievable. The geometry of the top and bottom surfaces of the lignite blocks and the cutting geometry of the bucketwheel cannot be adjusted to each other so accurate. As we see it a reduction of the dilutions will be a reason for an increment of the mining losses, which is expected to be more than the reduction of the dilutions.

The experience of PPC s engineers dealing with the exploitation of lignite stands against our point of view as we are told. in this context the following section may, however be interesting.

1.2.4.1.3.3 Accumulated Dilution Effects

The minimum thickness for the selective excavation of intercalations defines one of two sources of the total dilution of the pure, undiluted lignite, the so called „embedded dilutions". The other component are the so called „surface dilutions". The quantity and the quality of the dilutions influence the quality of the lignite production. The dilutions are normally strata without analysis *[SCT 1.2.4.1.3.5]* or lignite layers with an ash content higher than the cut off ash content.

The total dilutions result in a reduction of the calorific value. This reduction is a function of the quantity and the quality of the dilutions.

An investigation of this matter has been carried out by the LCPA *[SCT 7.3 - 24 - 0]* . In this investigation the strong influence of the dilutions on the lignite quality supplied to the powerstation is emhasised.

An interesting confrontation of the undiluted lignite and the diluted lignite actually supplied to the power station is presented. As a tentative figure the lower calorific value of the dilutions Cd is set at

Cd = -351 [kcal / kg]

The upper calorific value of the dilutions is assumed to be zero. The dilutions must then be

100 % ash (waterfree)

The actual ash a content of the lignite supplied to the Agios Dimitrios power station during the year 1989 was

a = 0,304 [--], (30,4 %).

The ash content of the undiluted lignite au was, however

au = 0,228 [--], (22,8 %).

Based on these figures the fraction of dilutions in the lignite actually supplied to Agios Dimitrios qd can be calculated as follows, (The ash content of the dilutions: 1,00 [--]).

a = au · qu + ad · qd

qu [--] = Fraction of undiluted lignite in the lignite production

qd [--] = Fraction of dilutions in the lignite production

qu + qd = 1

qd = (a - au) / (ad - au) = (0,304 - 0,228) / (1,000 - 0,228) = 0,098 [--]

The calorific value of the lignite supplied to Agios Dimitrios C is given as

C = 1 360= [kcal / kg]

The calorific value of the the undiluted lignite Cu is at the same time

Cu = 1 470 [kcal / kg].

The actual calorific value Cd' can now be calculated on the basis of the parametres presented above as follows:

C = Cu · qu + Cd · qd

C - Cu · qu = Cd · qd

(C - Cu · (1-qd)) / qd = Cd = (1 360 - 1 470 · (1-0,098)) / 0,098 = 347,6 [kcal 7kg]

The calculated calorific value Cd' must be equal to the initially assumed figure Cd. This does however not apply.

the calorific value of the dilutions Cd assumed in the calculation above must be too low by far.

In *[ATT 14 - 25]* a consistent data set for ad, qd and Cd has been determined. The ash content of the dilutions has been overestimated and the calorific value of the dilutions has been underestimated correspondingly.

The result of the investigation of the LCPA, we have been analysing above is the assessment of a thickness of the dilutions per lignite layer of block of

5 [cm] up to 20 [cm]

This thickness of the dilutions is too low as shown above. Additionally we see no justification to assume a figure close to the underestimated lower limit for the accumulated thickness of the dilution of a lignite layer or block in mines , whith geological conditions as complicated as the West Field North and the West Field South.

In the past we have been involved in the evaluation of a multi layer deposit similar to the PPC mines in Hungary. A more detailed analysis of this deposit has been started recently. In this case the calorific value of the intercalations has been analysed. According to this analysis the calorific value of the intercalations is in the order of

800 - 1 000 [kcal / kg].

The reduction of the dilution thickness is clearly a step into the wrong direction. We do not adopt the LCPA s decision, to apply an accumulated dilution thickness of

7 [cm]

for the future masscalculations *[SCT 7.3 - 19 - 0]*

Instead of that the calorific value of the diluting intercalations is to be determined for the calculation of the quantity of this material.

This is no serious problem because the operating mines provide an easy and quick access to these materials. Later PPC s exploration activities are another source of information in this context. As input for the calculation of the calorific value of the dilutions we need:

- The ash content (Waterfree including C O2),
- the water content and
- the lime content of the intercalations.

After the execution of this activity a review of the masscalculations for all PPC mines is suggested.

1.2.4.1.3.4 Cut Off Limit for the Ash Content & Calorific Value

The quality and the quantity of lignite depend on the cut off limit for the ash content in any case. In PPC s multi layer deposits this effect is, however, much stronger than observed in other cases.

Accordingly the cut off ash content cannot be set as a fixed input parameter for the masscalculation. It is to be adjusted in an iterative calculation process, until the average calorific value of the lignite is slightly above the power station s specification.

This specification presents normally three figures for the calorific value. these three figures are:

- The upper limit of the calorific value.
- the preferable calorific value,
- the lower limit of the calorific value.

In the most cases the preferable calorific value is equal to the lower limit.

This does not apply to the Agios Dimitrios power station and to the Megalopolis power stations.In these cases a calorific value below the specified preferable figure, slightly above the lower limit has been selected, in order to avoid signigicant decrements of the remaining reserves.

This is another area, where the discussions with our partners in the lignite centres resulted in changes.

Our statement, that the cut off ash content is input for the masscalculation and masscalculation result at the same time due to the iterative character of these calculations appears to be accepted.

1.2.4.1.3.5 Strata without Analysis

The calculation of the average quality parameters requires quality figures for all strata, which contribute with their full thickness or with a part of it to a lignite block. These are all layers from the waste layer on top of the uppermost lignite layer until the waste layer below the lowestmost lignite layer.

A review of the original drillhole information shows however, that this precondition is not fulfilled in any case.

In many drillholes we find layers classified as waste or lignite, which have not been analysed for unknown reasons. The exploration drillhoses are core drillholes. Where no core has been obtained, there are of course no quality data for the lost layers.

In all these cases quality figures are to be assumed. In the early phases of the project these quality figures have been assumed as

Ash content	:	100	%
Water content	:	30	%
Calorific Value	:	-500	[kcal / kg]

This is very conservative according to the following reasons:

- The layers without analysis are not waste only. An unknown fraction has been specified as lignite and the core loss includes for sure lignite layers. In *[SCT 1.2.2.1.1.1.3]* the core loss in the lignite bearing series is quantified as about

  10 %.

  About 50 % of this core loss might be lignite layers. According to this consideration about

  2,5 %

  of the thickness of the lignite bearing series are regarded as waste at present although they are lignite.

Even the layers specified as waste, cannot be assumed as 100 % ash *[SCT 1.2.4.1.3.3]*.

According to these considerations we introduced an adjusted set of quality data for the strata without analysis for each mine These data set is still a conservative approach as we see it.

We see however possibilities to remove the above described inaccuracies:

- The missing lignite quality in the case of core losses can be substituted after having correlated the deposits.
- Additionally geophysical logging is an appropriate method for the determination of the missing quality information in the case of core losses *[SCT 7.3 - 5 - 0 & 6 - 0]*.
- In the future all strata from the waste layer atop the uppermost lignite layer down to the waste layer below the lowestmost lignite layers must be analysed *[SCT 1.2.4.1.3.3]*.

1.2.4.1.4 The Calculation of average Block Qualities

Inconsistencies of the ash and water content on the one side and the calorific value resulting to the two aforementioned parameters were the reason to check the calculation formulae for the ash- and the water-content

1.2.4.1.4.1 Ash Content

We identified several reasons for inaccurate ash content figures

The initial screen for the manipulation of the input data for the masscalculations allows for setting an average value for the density of waste (1,8 t/m³) and lignite (1,2 t/m³). These figures are the densities as received, which are used for the calculation of all average quality data, The ash content is, however, not to related to samples including water but to dry matter. For the calculation of the average ash content the dry densities are to be applied. The density of wet samples can easily be converted to the dry density by application of the formula

ρ_d	$= \rho_r \times (1 - w)$	[t/m³]
ρ_d	= dry density	[t/m³]
ρ_r	= density, as received	[t/m³]
w	= water content, as received	[--]

The computer calculated ash content of lignite blocks, resulting to the computer was higher than the cut off ash content in some cases.

This was a consequence of the fact, that the ash content of each lignite block was compared to the cut off ash content prior to the application of the mining losses and the dilutions. This is not correct correct, because the subtraction of the mining losses , followed by the addition of the dilutions will result to an increased ash content.

The ash content figures, as the other lignite quality parameters figures calculated by the computer, were slightly different from the manually calculated figures.

This was due to the fact, that mining losses and dilutions were taken into account only for the adjustment of the lignite density. The water content, the ash content and the calorific value were not adjusted according to the mining losses and dilutions.

The necessary remedy measures have been introduced in the meantime.

1.2.4.1.4.2 Water Content

Apart from the aforementiones reason for a small inconsistency of the water content figures -mining losses and dilutions taken into account for the density only *[SCT 1.2.4.1.4.1]* another reason for a big deviation from the correct average water-content figures has been detected recently.

Masscalculation results indicate, that the input of missing water content figures in the case of incomplete quality data sets results to false average water content figures. This effect has been observer since long. Up to now we have applied a remedy procedure, described before (Introduction of the present, actual water content figures aincluding a correction factor according to the future depth of the mine, which will reduce the future water content).

The analysis of the aforementioned masscalculation results provided evidence, that the quality parameters for layers without analysis are also applied for the completion of incomplete data sets. Whenever the ash content is available but the water content is missing, the water content of the strata without analysis is applied.

As we see it, this procedure can reduce the average water considerably, if there are many incomplete data sets as describedabove.

Based on geotechnical considerations ash-free lignite is expected to have a much higher water content than lignite-free waste. in PPC s multi seam deposits the ash content varies within wide limits. accordingly one should expect water-content figures, which are related to the ash content figures. An increasing ash-content should result in a decreasing water con-tent. and vice versa.

These considerations are proven by a statistical analysis of the available ash- and water content figures in the Horemi mine *[ATT 14 - 20 &21]*. As assumed before, the water content is decreasing as the ash content is increasing. The average ash content per drillhole varies between about 40 % and about 55%. The corresponding water content figures (Trend: y' = mx + b) vary between about 63 and about 52 %.

In the case of missing water content figures it makes more sense to calculate the missing figures by the application of the trend function in attachment 1 than to apply the watercontent for the layers without analysis. These figures are much too low.

A bad correlation factor is not so important in this case, from our point of view. The concept can be adopted in spite of that:

- The relation between ash- and water-content must not be proven. it is a well known fact, that lignite has a higher water content than waste.
- Other influencing factors as the depth and the composition of soil and lignite have not yet been taken into account. We espect, that this wil result in a much better correlation.
- The application of our regression function is in any case more accurate than the application of the water contet for the layers without analysis or of an average water content.
- The mumber of quality data sets without water content figures is small, after we received the up to July 95 missing drill logs for the LCM.

An algorithm for the above described purpose has been designed integrated into the „METAL" package in the meantime.

1.2.4.1.4.3 Density

All density calculations result to assumed density figures for lignite

1,2 [t / m³]

and waste

1,8 [t / m³].

Actual density figures have not been analysed. As we see it this cannot correspond to the reality. The actual density figures must vary within wide limits for lignite and waste according to the variation of the ash content.

The present lack of actual information did, however not allow for any remedy measures. The analysis of lignite and intercalation densities is suggested for the future to the benefit of the accuracy of masscalculations and for geotechnical purposes. Stability calculations with only rough assumptions for the density of the strata are of litle value only. An additional important use for the density of lignite and waste is the calculation of the drive power requirements.

1.2.4.1.5 The Calorific Value for Mine Model Quantities

Waste and lignite thicknesses and the lignite quality parameters, obtained by the above described procedures, are then assigned to the corner points of the masscalculation grid by an interpolation algorithm for the subsequent mass calculation. This refers to the calorific value as to the other quality parameters as well.

As we see it today this procedure is one of the reasons for the fact, that the calorific values calculated with „METAL" did not correspond to their input data (Ash content, water content & lime content) upto now.

In order to check this matter we need an algorithm for the calculation of the calorific value

calorific value = f (ash content, water content, lime content).

This formula and ist application for the determination of the calorific value at the corner points of the masscalculation grid is described in the following sections of this report.

1.2.4.1.5.1 The Formula for the Calculation of the Calorific Value „C"

There is a possibility, to calculate the calorific value of PPC s lignite as follows:

$$C = Cc \times (1-w) \times (1-a) + Ca \times (1-w) \times a \times l + Cw \times w \text{ [kcal / kg]}$$

The symbols in this formula are defined below:

C	=	Calorific value of the lignite	[kcal/kg]
Cc	=	Calorific value of the ash- and waterfree combustible matter	[kcal/kg]
Ca	=	Energy consumption for the conversion of $CaCO_3$ to CaO	[kcal/kg]
Cw	=	Energy consumption for the evaporation of water	[kcal/kg]
w	=	Water content of the lignite (As received)	[--]
a	=	Ash content (Dry matter, including CO_2)	[--]
l	=	Lime content of the ash (Dry matter, including CO_2)	[--]

The following comments can be made about the variables in the list above:

Cc = Calorific value of the ash- and waterfree combustible matter [kcal/kg]

Our analysis of the actual lignite quality during the years 1983 - 1992 indicates, that a constant calorific value of the water- and ashfree combustible matter for each mine can be assumed *[ATT 8 - 1]* . At present this assumption is the only possibility, to calculate calorific values for the most PPC mines.

During the preparation of the TMMP a study of the mine limits and the geological lignite reserves of the West Field has been carried out *[SCT 7.3 - 13 - 0]* . A much higher calorific value for the ash and water free combustibles than assumed by the Masterplan Team is mentioned in this study. The Quality figures presented in this study are, however, not consistent. They result in a calorific value of the lignite, which is much too high *[ATT 14 - 24]*.

There is no possibility, to calculate the calorific value of the ash- and waterfree combustible matter in the lignite Cc for a sufficient number of drillholes providing the complete data set described above in the most mines *[SCT 1.2.4.1.6]* .

The future drilling program *[SCT 1.2.1.1.1]* and the regular analysis of the quality parameters of the lignite production for each mine *[SCT 4.1]* will improve the data base for the calculation of the calorific value Cc of the ash- and water-free combustible matter in the lignite.

Ca = **Energy consumption for the conversion of $CaCO_3$ to CaO** [kcal/kg]
This parameter is known:
Ca = -437 [kcal/kg], (Per kg $CaCO_3$)

Cw = **Energy consumption for the evaporation of water** [kcal/kg]
This variable is also known:
Cw = -583 [kcal/kg]

w = **Water content of the lignite (As received)** [--]
A certain fraction of the drillholes in PPC s geological data base includes no water content. It has been described before, how the missing water content figures can be substituted *[SCT 1.2.4.1.4.2]*. This applies to a restricted number of drillhoes only *[SCT 1.2.4.1.6]*.

a = **Ash content (Dry matter, including CO_2)** [--]
We use the ash content including CO_2 , because this results to a simpler formula for the calculation of the calorific value of the lignite C. The geological data base does not include this parameter in any case *[SCT 1.2.4.1.6]*. If the lime content in the ash is known (See below), the ash content without CO_2 can, however be converted to the ash content with CO_2 without problems.

l = **Lime content of the ash (Dry matter, including CO_2)** [--]
This parameter is not known in any case *[SCT 1.2.4.1.6]*. Only if the ash content without CO_2 and the ash content with CO_2 is known, the lime content of the ash can be calculated.

Fortunately the lime content of the ash is of minor importance for the calorific value of the lignite C. Our analysis of the actual lignite quality during 1983 - 1992 indicates additionally, that a constant lime content for each mine can be assumed. These figures have been presented in our previous reports *[ATT 8 - 1]*.

Another option is to improve the available data base by the future drilling program *.11.2.1.1]*, and to calculate the lime content of the ash for the corner points of the masscalculation grid based on this information with the interpolation algorithm. The analysis of the quality parameters for the lignite production of each mine could provide additional information in future *[SCT 4.1]*.

The formula described in this section of the report has been integrated into PPC s masscalculation software package „METAL". We regard this as an important contribution to the accuracy of masscalculations with this software package. There is no other way to achieve calorific values, which correspond to their input data ash content, water content and lime content.

1.2.4.1.5.2 Application of the Formula for the Calculation of the Calorific Value „C"

The calculation of the average calorific value for a mine model is especially important. As we know today there is a strong relation between the calorific value and the reserves in the mine model. Accordingly an iterative calculation is to be executed, where the cut off ash content is varied, until the calorific value is only slightly above the power stations specification, because only then the maximum exploitable reserves are achieved. Inaccuricies of the calorific value results will significantly influence the reserves.

In this context the following subjects are to be taken into consideration:

- Can the available calorific value figures be used as input for the interpolation?
- Calculation of the calorific value at the grid points with interpolated ash-, water- and lime-content figures as input?

Interpolation of the available Calorific Values:

There are two reasons, why the available information for the calorific value should not be used for the interpolation of the calorific value at the corner points of the masscalculation grid.

The calorific value of each layer and the input data for the calorific value of this layer will not correspond to each other in any case, because all these figures can only be determined with a certain accuracy. In order to remove this inaccuracies, it is a suitable approach, not to use the available figures for the calorific value as an input for the interpolation.

The calorific value of the strata has only been analysed for a small fraction of the drillholes. The calorific value at the corner points of the masscalculation grid is then calculated based on these few figures with the following interpolation algorithm:

$$P = \sum (P / d^2) / \sum (1 / d^2)$$

P =	Parameter, to be interpolated (In this case the calorific value)	
d =	Distance corner point of the masscalculation grid from drillholes	[m]

At the same time the ash- and water content figures at the corner points of this grid are determined by the same interpolation algorithm based on much more information about these parameters. The different density of information referring to the ash- and water content on the one side and the calorific value of the other side is under this circumstances expected to set different trends for the assignment of ash- and water.content figures or calorific values to the corner points of the masscalculation grid.

These trends must, however correspond to each other, because the calorific value results to the ash and water content. The ash. and water-content on the one side and the calorific value on the other side cannot be assigned to the corner points of the masscalculation grid independently on each other. The existing mathematical relations between these parameters must be observed.

Hence we cannot expect, that the interpolation algorithm results to the same figures for the calorific value as the calculation of the calorific value. This assumption has been checked in *[ATT 14 - 22 & 23]* .The interpolation of the average calorific values for a drillhole results in figures different from the calculation of the calorific value for the gridpoints based on the interpolated input data

This is the second reason, why the available calorific value information should not be used as the input for the interpolation of the calorific value

Calculation of the Calorific Value at the Grid Points:
The solution of a problem can freqently be found by excluding the approaches, which are not applicable.

If we apply this principle, the calculation of the calorific value at the corner points of the masscalculation grid with interpolated figures for the ash-, water. and lime content as input remains as the only applicable solution.

An adjustment of „METAL" has been introduced in the meantime.

1.2.4.1.6 The Input Data for Masscalculations (Digital Quality Model)

The objective of the installation of a geological deposit model is the calculation of waste quantities (lignite and waste) and of quality parameters (Ash-, water. and lime-content, Calorific value and density). As we know today inaccuracies of the input of quality data in the digital deposit model have been one of the reasons for the inconsistent masscalculation results,which have been observed since long.

One reason for a major inaccuracy of the quality input -the substitution of missing water content figures by the water content of the strata without analysis- has been removed in the meantime *[SCT 1.2.4.1.4.2]* . There are. however, four areas of concern left. These areas are:

- The completeness of the drillholes implemented in the geological model
- Applicability of the available drill hole information.
- Quality parameters of restricted accuracy.
- The quality of the strata without analysis

1.2.4.1.6.1 The Completeness of the Drillholes in the Geological Model

We may not yet have received all available drill logs for the implementation of the geological model.

Comments of our counterparts in the LCPA in context with the masscalculation for the West Field North and a statement in *[SCT 7.1 - p.3]* result in this assumption.

in this context it is to be mentioned, that the majority of the drill logs for LCM were not available to us until August 1995 after having serched for them at any potential source of information including the university institute of Prof. Goergen.

As a result of the aforementioned discussions with our counterparts in the LCPA we received a diskette with additional drill logs for the West Field North in November 1995.

The accuracy of our masscalculations depends, however on the quality and completeness of the drill hole information. The total number of drillholes in each mining area, which have been used for our geological model is shown in *[ATT 14 - 19]* .Prior to the next review of the TMMP the geological model should be actualised and completed.

1.2.4.1.6.2 Applicability of the Available Drill Hole Information

Apart from the fact, that not all drill logs have been provided to the Masterplan Team, the available drill logs do not include the complete set of quality information, which is required for the calculation of the calorific value as described in *[SCT 1.2.4.1.5]* in any case. In the cases described below there was no remedy measure. We had to exclude these drillholes from the gelological model.

The following reasons, to exclude various numbers of drill holes are to be mentioned:

Drillholes without Quality information:

A small number of drillholes did not provide any quality information. We had to exclude them from the implementation in the geological deposit model.

Unreliable Drillholes:

Another small number of drill logs was marked with the inscript

„unreliable"

for certain reasons. These drillholes have also been excluded from our geological model.

Evaluated Drillholes:

For another fraction of the drillholes the original drill log was no more available. These holes were already evaluated with an unknown set of evaluation criteria. Changed thicknesses for the deposit evaluation and especially the inevitable variations of the cut off ash content result, however, in corresponding changes of the lignite and waste blocks and in changing positions of the top and bottom of lignite. Accordingly we had to exclude these evaluated holes.

The number of drillholes in each mining area, which had to be excluded from the geological model are presented in *[ATT 14 - 19]*.

Prior to the next review of the TMMP, it is suggested to search for the missing original drill logs in the case of the evaluated holes. A detailed investigation of the unreliable drill holes is suggested additionally.

1.2.4.1.6.3 Quality Parameters of Restricted Accuracy

There are four deposit characteristics for the calculation of the calorific value *[SCT 1.2.4.1.5.1]*:

- The ash-content,
- The water-content,
- The calorific value of the ash- and water-free combustible matter and
- the lime content in the ash

The sufficiently accurate description of the variation of the ash- and the water-content in the deposits requires a bigger data base than the corresponding description of the calorific value of the ash- and water-free combustible matter in the lignite and of the lime content in the ash.

Ash-Content and Water-Content:
After having received the original drill logs for the LCM mines there is only a small number of drill holes without water-content figures *[ATT 14 - 19]*. In these cases we have replaced the water content addording to the results of a regression analysis *[SCT 1.2.4.1.4.2]*.

Our counterparts in the LCPA have expressed their concern about the accuracy of this remedy measure introduced by the Masterplan Team.

We regard our approach as applicable. Our intention was, to exclude the lowest possible number of drillholes from the geological model.

Calorific Value & Lime-Content:
The calorific value of the lignite and the lime content of the ash are together with the ash conten and the water content the input for the calculation of the calorific value ofthe ash and waterfree combustibles in the lignite.

In this case the data base is really poor *[ATT 14 - 19]*. Fortunately the lime content in the ash has an only small influence on the calorific value C of the lignite and, if this figure is known, on the calorific value of the ash- and water-free combustibles in the lignite.

According to our investigation of the actual lignite quality supplied to the power stations, both parameters vary only within narrow limits. Hence we assumed the lime content l of the ash and the calorific value of the ash- and water-free combustibles in the lignite as constants for each mine *[ATT 8 - 1]*.

This assumption results in a small inaccuracy of the calorific value and correspondingly of the reserves of exploitable lignite. We were, however forced to proceed as desribed above. Without these assumptions and without the introduction of the formula for the calculation of the calorific value we would not have been in the position, to set up the iterative type of reserve calculation, we have introduced *[SCT 1.2.4.1.3.3]*, and there is no rasonable reserve calculation without the application of theis procedure.

1.2.4.1.6.4 The Quality of the Strata without Analysis

The missing quality figures for the strata without analysis are the most important area of concern in context with the input data for the calculation of the average quality parameters and the remaining reserves. Their influence on the average calorific value may have been underestimated if not neglected in the past, although well known geological facts indicate, that the intercalations in PPC s multi layer deposits must contain considerable fractions of combustible organic matter.

At the beginning of our work the following quality parameters of the strata without analysis were normally applied for masscalculations with „METAL". A water- content w, an ash-content a ' (waterfree, CO_2 excluded and a calorific value C for the intercalations is taken into account:

w	a '	l	Cc	C
[--]	[--]	[--]	[kcal / kg]	[kcal /kg]
0,30	1,00	--		-500

The ash content a' (Waterfree, CO_2 excluded)´of 100 % indicates that the intercalations were assumed to contain no organic matter. The lime content l of the ash has been neglected as well.

For the subsequent considerations we have introduced the ash content a (Waterfree, including CO_2). this results in simpler calculation formulae.

In *[ATT 14 - 24 & 25]* The calorific value C_d of the strata without analysis has been calculated as a function of the ash content of these strata. We assumed, that the ash contend a_d might vary between

$100\ \% > a_d > 70\ \%.$

RE s Geologist mentioned in a conversation about this matter, that an ash content in this order of magnitude might apply. This results in a calorific value between

$-391 < C_d < 572$ [kcal /g].

Only small changes of the composition of the strata without analysis have a strong influence on their calorific value and the calorific value of the strata without analysis influences the lignite reserves considerably.

The calorific value of the strata without analysis has been underestimated. This parameter influences, however, the reserve calculation result considerably. For the next review of the TMMP the quality parametres of the intercalations should be analysed (Ash content -dry matter including CO_2- water content and the lime content of the ash).

1.2.4.2 The Remaining Reserves of the LCPA

The assumptions and procedures, described above, result to the remaining reserves of the LCPA.

The limits of the mine areas, as assumed in the past according to the masscalculations carried out in the TMMP for the Ptolemais and Amyntaion mines are shown in attachment *[ATT 15 - 1 & 2]*. These limits have been set at a cut off mining ratio of 8 - 10 : 1 [m^3 / t].

In attachment *[ATT 15 - 3*] the accumulated production figures until 30.06.1993 are presented. In *[ATT 15 - 4]* the accumulated production figures until 30.06.1993 are subtracted from the original masscalculation results, to determine the remaining reserves on the 01.07.1993 (Start up date of the TMMP for the LCPA).

The remaining reserves, resulting to this calculation are confronted with the masscalculation results, carried out by the Masterplan Team in attachment *[ATT 15 - 5]*.

The ecomomically exploitable reserves are presented in *[ATT 15 - 6]*. The reserves in the Sarigiol Section of the South Field *[ATT 15 - 6, N°1.3.2]*, of the Proastio mine *[ATT 15 - 6, N° 1.3.]* and of the east Field *[ATT 15 - 6, N° 1.5]*, are not included in these reserves due to economical considerations.

In Attachment *[ATT 15 - 7]* the remaining reserves (TMMP calculation), the criteria of evaluation, applied by the Masterplan Team, and the average quality parameters are shown.

In attachment *[ATT 15 - 8]* the remaining reserves have been assigned to the power stations in order to minimise the costs of lignite transportation.

These reserves have been used as input for the determination of the period of operation for the power stations *[SCT 1.1.7]*.

The reserves in the safety pillars of the Ptolemais and Liptol Power stations are free for the exploitation after the demolition of the power stations. The reserves in the safety pillar of the Liptol power station can only be consumed by the Ptolemais power station.

The reserves in the safety pillar of the Ptolemais Power station have been assigned to the next consumer after the demolition of the Ptolemais power station, which is the Kardia power plant.

The reserves in the safety pillar of the Kardia power plant are to be consumed by the Agios Dimitrios Power plant after the demolition of the Kardia power plant. Because the calorific value for the Agios Dimitrios power station is lower than the calorific value for the Kardia power station, the reserves on the safety pillar of the Kardia power station have been re-evaluated according to the specification of Agios Dimitrios.

Since the reserve calculation described above has been completed, essential basic assumptions and facts, which influence the remaining reserves and the mining ratio have changed. Changes as such are:

- Considerable improvements of PPC s masscalculation software package „METAL" have been achieved.
- There are reasons to assume, that the calorific value of the strata without analysis has been underestimated in the past.
- The option, to blend the mine procuction having a calorific value below the power stations specification with dry lignite having a calorific value above the power station s specification has been introcuced as an option to be investigated(Ptolemais & Kardia Power stations.
- In the case of the Amyntaion power station we learnt in a discussion with our conterparts in the LCM that a calorific value below the power station s specification of about 950 [kcal / kg] is sufficient for the full load operation of the Amyntaion power station.

In our previous masscalculation the lower limit of the calorific value has not been maintained in any case. This inconsistency is to be removed, according to the strong relation between calorific value and reserves.

To check the combined effects of these changes an alternative evaluation of the LCPA deposits has been prepared *[ATT 15 - 9 & 10]*:

- The reserves assigned to the Liptol and Ptolemais power stations (1.1.2 + 1.1.3 + 1.2.2.2) remain (unfortunately) unchanged. The development of the West Field North cannot be postponed.
- The reserves of theWest Field North itself are considerably higher.
- There are considerable more reserves in the Sector 6.
- The reserves in the West Field South out of the safey pillar of the Kardia power station are above the previous reserves.
- The reserves in the safety pillar for the Kardia power station itself are smaller. We have increased the calorific value to be supplied to Agios Dimitrios, because the West Field South is to supply the major fraction of the lignite for this power station during the exploitation of the safety pillar of Kardia.
- The reserves in the main field of Amyntaion are considerably higher and the mining ratio is lower.

These results are again indicating the necessity, to investigate the quality of intercalations in the lignite bearing series. Additionally it is suggested to analyse the option, to produce dry lignite for blending purposes in the LCPA.

1.2.4.3 The Remaining Reserves in the LCM

criteria of evaluation. Hence we regard the evaluation results in *[SCT 7.3 - 7 - Vol. 1]* as not applicable.

An area of concern is the water content of the Kyparissia lignite in the TMMP calculation. This figure is too low. At the same time the water content figures for Horemi and Marathousa are too high. The reason for both deviations is the late availability of the original drill hole information for the LCM *[SCT 1.2.4.1.6.1]* .Due to the lack of this information we had to introduce simplifying assumptions for the water-content. These emergency-assumptions have not been sufficiently accurate.

As in the case of the LCPA reserves a lot changes referring to parameters influencing the results of our reserve calculations have taken place since the calculation presented above has been executed. Apart from the four changes listed in *[SCT 1.2.4.2]* the geological data base for the LCM is to be mentioned additionally, which has been improved by far in the meantime.

The effect of all these changes has been checked in an alternative evaluation of the LCM deposits *[ATT 16 - 8]* :

- In the LCM the new reserve calculation results in reduced remaining energy reserves.
- The reserves of Horemi and Marathousa together are higher than in our previous calculation.
- In the Kyparissia mine considerably lower reserves remain exploitable according to our new calculation. In this context the low calorific value of the exploitable undiluted lignite is to be mentioned *[ATT 14 - 27]* , which is slightly below the specification of the power station. The bad average quality of the Kyparissia lignite and the evaluation procedures applied in the past are the reason for the small small remaining reserves calculated recently by the Masterplan Team.

The conclusions referring to the analysis of the quality of the intercalations, we have presented in the case of the LCPA apply to the LCM as well. A review of the masscalculation after having executed this activity is proposed by the Masterplan Team.

1.2.4.4 Conclusions: Remaining Reserves & Mining Ratio

Within the mine fields of the LCPA and the LCM the evolution of the mining ratio and the balance of dumping volumes is to be determined by a sector wise masscalculation. The results of these calculations are the most important basis for the conceptual planning of both lignite centres and the individual mines as well.

Corresponding to these considerations the reserve figures presented above are to be judged. The following statements are presented in this context:

In the case of PPC s lignite deposits the quality requirements of the power stations have an important influence on the remaining lignite reserves *[SCT 1.1.3]*. The planning work of the TMMP is based on the guideline, that no other fuels than lignite are to be supplied to the power stations of the LCPA and the LCM. The consequences of blending lignite with a small quantity of e. g. dry lignite are, however, considerable. The concept of mining, presented by the TMMP, would be influenced by far, if this measure is adopted (Increased remaining reserves at a lower mining ratio, lower requirements of equipment, reduced requirements of lignite transportation).

Another area of concern is the status of the deposit exploration.

The data base (Quality parameters of the deposit strata especially for the so called strata without analysis) for the implementation in the geological model *[SCT 1.2.1]* is to be improved. Rough assessments of the quality parameters of the strata without analysis are available in the meantime *[SCT 1.2.4.1.6.4]* .These reaults are a reason, to emphasise the nesessity of these investigations.

In order to achieve the accuracy of the deposit model, required for long term planning purposes, about 228 additional drill holes are regarded necessary *[SCT 1.2.1.1.1]*.

The hydrological situation has not yet been sufficiently investigated *[SCT 1.2.2]*.

The slope inclinations, assumed for our planning work are to be reviewed based on the results of the geological and hydrological investigations *[SCT 1.2.3.]*.

The present sector wise masscalculations, which are the base for our subsequent planning work are not sufficiently accurate due to several reasons described in *[SCT 1.2.4]* .

the remaining reserves and the mining ratio, resulting to our masscalculation are not regarded sufficiently accurate due to the reasons described in this section of the report. After having improved the data base as described above a review of the masscalculations for PPC s long term planning is proposed by the Masterplan Team.

1.3 PPC` s Main Mine Equipment

The third main data collection activity of the TMMP refers to the mine equipment. The capacity of the mine equipment must correspond to the requirements of total excavation, which are determined by the lignite demand of the power stations *[SCT 1.1]* , by the mining ratio *[SCT 1.2]* and by the utilisation of the main mine equipment, which is to be dealt with in the following sections of this report.

The present actual ulitisation figures are much too low. Theoretical investigations and the comparison of the utilisation figures obtained in PPC s mines with corresponding standard figures result in this statement.

A more detailed justification requires considerations referring to the following subjects:

- Utilisation parametres used in this report
- Constraints for the utilisation of PPC s mine equipment
- Presentation of the actual utilisation figures achieved in the past
- Assessment of the future utilisation.

1.3.1 The Utilisation Parametres applied by the Masterplan Team

The discussion of PPCs equipment utilisation requires clearly defined utilisation parametres, which are understood by both sides.

In order to allow for the comparison of PPC s utilisation figures with the equipment utilisation e. g. in Rheinbraun s mines, we applied the utilisation parametres used by Rheinbraun for the evaluation of the available PPC data. The definition of these parametres is to be demonstrated prior to their use in this report.

The basic relations between utilisation parameters applied in this report are:

- theoretical capacity × block factor „ b “ = nominal capacity,
- nominal capacity × load factor „ l “ = effective capacity,
- calendar time × (1 - parameter „ p ") = mine operation time,
- mine operation time / (1 + parameter „ s ") = equipment operation time
- mine operation time / calendar time = time factor „ t "
- Load factor „l" × time factor „t" = utilisation factor „ u „.

- Accumulated utilisation parameters: If e.g. the utilisation factors for a total mine are to be calculated based on the figures for the individual machines, basic mathematical relations are to be observed. As these relations are easily neglected the correct calculation procedure for cases as mentioned above is described.

1.3.1.1 Theoretical Capacity × Block Factor „ b „ = Nominal Capacity

Our considerations start with the theoretical capacity of a bucketwheel excavator:

The theoretical capacity

-theoretical capacity = nominal bucket volume × discharges / hour [lm³ / h]-

is not the appropriate figure for the judgement of the excavator capacity, because the ecavator cannot release it at any point of time.

Whenever the slewing direction of the bucketwheel changes, the bucketwheel is moved to the next slice of the frontblock and the flow of material released by the excavator decreases to zero for a moment.

The same applies when the excavation of the next slice in the frontblock or of the next frontblock commences.

The capacity losses related to these changes of the flow of material depend on the construction of the bucketwheel excavator. The quotient

length of the bucketwheel boom / bucketwheel diameter

is regarded essential in this context *[SCT 7.3 - 9 -0 , SCT 7.3 - 10 -0 & SCT 7.3 - 11 - 0]*. The average flow of material of compact excavators, where this quotient is small, is considerably smaller than in the case of normal bucketwheel excavators, where this quotient is big.

Accordingly utilisation figures for different bucketwheel excavators cannot be judged based on the theoretical capacity. The correct parameter is the nominal capacity. The theoretical capacity multiplied with the so called „block factor results in the nominal capacity. It takes into account the above described capacity reductions during the excavation of a normal front block (Normal block height and width, standard slope inclinations for the front slope and the side slopes normal material properties, no capacity restrictions related to the hardness or stickiness of the material, standard swell factor 1,3).

Under these conditions the block factor „ b „represents the capacity reductions resulting to the construction of the bucketwheel excavator.

The nominal capacity Q_n is then the product of the theoretical capacity Q_{th} and the block factor b, divided by the standard swell factor 1,3

$Q_n = Q_{th} \times b / 1,3$

The actual swell factors of the different kinds of material are taken into account in the load factor, which reprewents the influence of the material and of the actual block geometry.

The nominal capacity for PPC s excavators was not available for our capacity assesment. Because many compact bucketwheel excavators are employed in PPC smines and in order to compare PPC s utilisation figures with the equipment utilisation in other lignite mining areas this missing parameter had to be determined by the Masterplan Team. For this calculation the volume of the normal front block is divided by the total time for its excavation.The resulting capacity in [l m³ / h] is then converted into [b m³ / h] by the application of the aforementioned standard swell factor.

The results of this calculation are shown in attachment *[ATT 17 - 1 / 4]* . The drive units of some of the PPC excavators have a shiftable gear box. In these cases up to three discharge rates resulting in up to three theoretical capacities and nominal capacities can be selected. In order to be on the safe side we assumed the lowest discharge rates for the subsequent considerations.

1.3.1.2 Effective Capacity = Nominal Capacity × Load Factor „l“

As mentioned above the block factor „ b “ comprises reductions of the theoretical capacity related to the construction of the excavators.

The capacity reductions related to the actual conditions at the excavation site, which are different from the normal conditions, assumed for the determination of the block factor „ b „ are comprised in the load factor „ l „.

This parameter includes the effects of the actual swellfactor of the material and of its hardness and stickyness. Additionally the influence of the actual block- and slice-geometry are taken into account.

The effective capacity Q_n multiplied with the load factor l is then the the nominal capacity Q_{eff}.

$Q_{eff} = Q_n \times l = Q_{th} \times b / 1,3 \times l$

1.3.1.3 Calendar Time × Parameter „ p „ = Mine Operation Time

In different mining areas the time available for the operation of the mines is different due to different numbers of public holidays. If there is an abundance of equipment capacity, this is to be taken into account additionally in a separate parameter in order to achieve comparable utilisation parameters.

This objective is achieved by assigning downtimes during public holidays, when the mine is closed down completely, and downtimes related to the capacity reserves in a mine to a special utilisation parameter. This is the parameter „p ". It is defined as the downtime P during public holidays plus the downtime related to reserve capacity divided by the calendar time C.

$$p = P / C \text{ [--]}$$

The Mine operation time M is then

$$M = (1-p) \times C \text{ [h/a]}$$

1.3.1.4 Mine operation time M × parameter „ s „ - Equipment Operation Time

All other downtimes not included in the parameter p are taken into account in the parameter „s".

It is defines as the quotient of all downtimes S (except the holidays plus reserve) divided by the equipment operation time E.

$$s = S / E$$

The equipment operation time E is then

$E = M / (1+s)$ - *[SCT 1.3.1.1.5]*

1.3.1.5 The Time Factor „t"

The time factor t is the quotient of the equipment operation time E divided by the calendar time C

$$t = E / C = (1-p) / (1+s)$$

this equation can easily be verified taking into account that

$$C = P + S + E$$

must be true. After division of the equation through C we get

$$1 = P / C + S / C + E / C = P / C + S \times B / C \times B + E / C$$

$$1 = p + s \times t + t = p + t \times (1+s)$$

$$t = (1-p) / (1+s)$$

1.3.1.6 The total utilisation „u“

The total utilisation u is the product of the time factor „t“ and the load factor „l“

$$u = t \times l$$

1.3.1.7 Accumulated Utilisation Parameters

A consistent system of accumulated utilisation parameters (for all machines in a mine during a year based on monthly figures) is achieved as follows:

The monthly times C, S, M and E are accumulated and the sums are then put in the aforementioned equations for „t“, „s“ and „p“.

For the calculation of the total utilisation „ u“ monthly total excavation figures are added. this sum is then divided by the accumulated products of the nominal capacities and the calendar time.

The accumulated load factor is then determined as the quotient of the acculmulated total utilisation and the accumulated time factor.

If this method is adopted, all equations mentioned before are fulfilled by the accumulated utilisation parametersas well.

1.3.2 Constraints for the Utilisation of PPC s Mine Equipment

The requirements of excavator capacity result to the necessary lignite release, to the mining ratio and to the achievable utilisation of the mine equipment system

This system consists of donors and receivers.The donors (Excavators) load an excavation conveyor. The capacity of both elements must be adjusted to each other.

The same applies to the receiving systems (Spreaders with their conveyor system and the lignite handling systems).

Hence the capacity of the main mine equipment is determined by the interaction of the elements mentioned above.

The following subjects are essential in this context

- the requirements of theoretical capacity in the mine system,
- the requirements of drive power in the belt conveyor system,
- The necessary adjustments of mine geometry and equipment geometry,
- Selective mining ,
- Hardrock removal,
- Influences of mine planning on the utilisation of the equipment,

1.3.2.1 Requirements of Theoretical Capacity

The theoretical capacity of the conveyor system serving an excavator, must be higher than the theoretical capacity of the excavator.

As a guideline the formula

theoretical capacty of the conveyor system = 1,1 × theoretical excavator capacity

is applied. The theoretical capacity of the receivers must again be higher than the theoretical capacity of the excavators in the system. In this case the formula

theoretical capacity of the receivers = 1,2 × theoretical excavator capacity

is applied as a guideline.

These rules have not been observed in PPC s mine systems in any case. We found theoretical capacities considerably above or below the guidelines mentioned above. Both deviations are to be removed. Where the theoretical capacity is too high, too much money has been spent and will be spent in future. Where the theoretical capacity is too low, the utilisation of the installed excavator capacity is restricted.

General proposals for the removal of these bottlenecks in the mine system have been prepared by the Thalis Symphonia Project.

1.3.2.2 Requirements of Drive Power in the Belt Conveyor System

The drive power requirements for the belt conveyor system tesult to the the weight of the material on the belt.

In this context the density of the material (to be investigated in future), the swell factor and the typical variation of the flow of material, created by a bucketwheel excavator, according to

- the slewing movements of the bucktwheel boom,
- slice- changes
- completion of a front block

during terrace cut excavation must be taken into account.

The flow of material is not equal to the theoretical capacity at any point of time. Beyond a slewing angle of about 60°*[SCT 7.3 -9 - 0, SCT 7.3 -10 - 0 & SCT 7.3 11 - 0]* , whenever the excavation of a new slice commences and when the excavation of the deepestmost slice has been completed the flow of material will be decreasing down to zero for different periods of time.

This results in an average load on the belt, which is below the theoretical capacity. This reduction depends on the length of the conveyor section under consideration. for long conveyor sections this reduction is equal to the block factor.

We checked the drive power requirements based on an conservative assessment of the average load on the belts in co operation with the ongoing activities in the Thalis Symphonia project. According to these calculations the belt conveyors in PPC s mines are not equipped with sufficient drive power in any case.

A lack of drive power results in a corresponding reduction of the load factor. Because restarting an overloaded belt conveyor system requires is to be unloaded manually, the mine crew tends to avoid it, as soon as they know about it. Thus the problem is hidden. Regular checkups of the drive power requirements in context with the yearly revies of the mines mid-termplanning *[SCT 1.3.2.1.5]* are the remedy measure in this case. The installation of belt scales, for a continuous supervision of the load factor is another applicable measure in this case.

1.3.2.3 Mine Geometry & Equipment Geometry

The adjustment of the bench elevations is an important tool for the steering of an opencast mine *[SCT 1.3.1.5]* .

This tool is, however only then applicable, if there are reserves of excavation- or dumping height left available. The accumulated ecavation- or dumping height of the equipment must be more than the maximum depth of the mine or the maximum depth of the expit and inpit dump (About 10 - 15 % is regarded sufficient).

Without the proper observation of this rule mine positions with benches hampering each other cannot be avoided by adjustments of the bench elevations. A reduced utilisation of the capacity will be the consequence.

1.3.2.4 Selective Mining

The effests of selectively mining are the most popular reason for the low eqipment utilisation.

Having a look on the multitude of this lignite and waste layers in an exposed mine face, one should however not forget, that not the individiual layers are to be mied selectively, but the so called blocks (composite units containign several lignite and waste layers. These blocks are much thicker than the individual layer.

As we see there is a trend, to overestimate the effects o selective mining.
Additioally we see th possibility to reduce these effects by the evaluation of PPC s multi layer deposits. The calorific value to be achieved should be as low as possible. In this case the number of blocks is assumed to decrease and their average thickness can be expected to increase.

1.3.2.5 Hard Rock Removal

The necessity to remove hard materials, which cannot be excavated by the BWE s is another popular reason for low utilisation parameters.

This must however not apply. The organised removal of hard material requires as the first step the knowledge of the hardrock deposit *[SCT 1.2.1.1.2]*. The methodology of hard rock removal as we see is is described in *[SCT 4.4.1]*.

Most likely the effects of hard rock removal are overestimated too from our point of view.

1.3.2.6 Mine Planning Effects

As a matter of fact conceptual long term planning tasks cannot be carried out sufficiently detailed for mid- and short term operational purposes.

The geometrical model of the deposit is normally not sufficiently detailed.

The long term prognosis for the performance of the eqipment holds true only for longer periods of time. The ulilisation during medium- and short periods of time will inevitably vary within limits, which become wider, as the period of time becomes shorter. The same applies to the lignite demand.

Accordingly the long term planning is normally carried out without benches. The missing details are added by mid and short term planning activities, which are to be reviewed regularly.

A good example for these activites is a benchwise planning,for the next 5 - 10 years, which is reviewed every year. This is then the base for the regular checkup of the drive power requirements *[SCT 1.3.1.3]*.

Another example is the adjustment of the bench heights according to the seasonal changes of the lignite demand *[SCT 1.1.5.2 & 4.1]* . By adjustments of the bench heights an increasing part of the excavator capacity is assigned to the operation in the lignite bearing series during the peak demand periods and vice versa. As we see it, the seasonal changes of the lignite demand require this kind of activity *[ATT 23]* . A big stockpile alone is not sufficient. Especially during the winter peak too much stockpile volume woud be required, to overcome the increment of the lignite demand during this period of time.

Additionally we find special problems in most of the PPC mines, which call for the application of the planning method described above (e.g. relocation of the belt distribution point, relocation of a river for the transition from on mine area to a subsequent one). The preparation of these activities calls for time schedules, which need to be actualised regularly.

The lack of mid- and short term planning activities as such results inevitably in a reduced utilisation of the mine equipment. Operational events (Belt shifting, extension of shortening of belts, transportation of excavators or spreaders) cannot be co ordinated with maintenance measures. Both kinds of downtimes cannot be planned and scheduled, in order to achieve the shortest possible duration of these activities.

It is our impression, that the effects of unsufficientmine planning activites are underestimated by PPC s mine engineers. Especially the so called internal mine planning units are understaffed. At present they cannot perform their tasks as required.

1.3.3 The Actual Utilisation Figures

Our invesigations referring to the actual utilisation of PPC s mine equipment has been comprised in *[ATT 17 - 5/16]*.

In *[ATT 17 - 5/8]* the average utilisation of the excavators in the LCPA, the LCM and for all PPC excavator has been analysed for the period of time from Jan 1991 until July 1993.

The following utilisation parametres for all PPC excavators together and in the two lignite centres have been achieved.

Area	p [--]	s [--]	t [--]	i [--]	u [--]
LCPA	0,192	1,015	0,401	0,507	0,203
LCM	0,558	*0,557*	0,284	*0,751*	0,213
LCPA & LCM	0,222	1,079	0,374	0,493	0,185

The average total utilisation achieved in the aforementioned period of time is much too low. There are, however, reasons for these low figures.

The average parameter „p" is in the same order of magnitude as in Rheinbraun s mines, which are operating at 300 days per year compared to 363 days per year in PPC s mines.

Up to 55,8 % of the installed mine capacity in the LCM is in a stand by position (Lack of belt conveyor material, equipment crews are not exchanged at the equipment).

In the LCPA many small excavators are kept idle due to the lack of spreader capacity. (If necessary the spreader capacity could be increased by increasing the belt velocity on the spreaders).

The high parameter p is regarded as a potential capacity reserve.

The parameter s achieved in the LCM indicates PPC s capability to achieve a high timely utilisation. Any Rheinbraum mine would be proud, to have achieved a figure as such. Our standard figure is in the order of

s = 0,75 [--].

Per hour of eqipment operation time the LCM needs only 0,558 [h] of unexpected downtime. The corresponding Rheinbraun figure is 0,75 [h] per hour of equipment operation time.

The load factor is another interesting figure. Again the LCM is the winner. An average load factor of 75,1 % is in the order of magnitude of our standard figures as well.

From our point of view the favourably low parameter s and the hich load factor in the LCM is a consequence of the necessity to achieve it. 55,8 % of the mine capacity were not available due to the reasons mentioned above. The lignite supply requirements were to be fulfilled with the remaining mine capacity. Because this remaining capacity was small, it had to be operated on a high level of utilisation.

A similar situation applies to the Amytaion mine in the LCPA. For one of the waste excavators there is no spreader available at present. The theoretical capacity of the two operating waste receivers is too low *[SCT 7.3 - 10 - 0]* . At the same time the the installed drive power of these systems is below the requirements.

The utilisation figures for the Amyntaion mine are presented in *[ATT 17 - 9]* . on page 1 of this attachment the waste excavators have been analysed. The number of waste receivers is too small at present *[ATT 17 12]* .

For one of the waste excavators there is no spreader available. Hence one of the waste excavators belongs to the capacity reserve at any point of time. Additionally the dump conveyor systems are most likely equipped with insufficient drive power.

Under these circumstances there are sufficient reasons for a low time- and load factor. Because the lignite release requirements are to be fulfilled on the other hand, one should, however expect the high parameter s shown in our evaluation.

The present utilisation of PPC s main mine equipment does not reflect the achievable level of utilisation. A high fraction of the available excavator capacity is kept in a stand by position without conveyor system. A certain excess capacity is additionally reducing the available level of utilisation. Finally bottlenecks in the transportation system (lack of theoretical capacity, lack of drive power) and a lack of mine planning result in the present low level of utilisation.

1.3.4 Assessment of the Future Utilisation

A detailed analysis of the future lelel of equipment utilisation has been presented by the Masterplan team before *[SCT 7.3 - 8 - 0]* .

This analysis results in the following utilisation parametres *[SCT 7.3 - 8 -77]*:

p 1	s 1	t 1	l 1	u 1
0,010	0,900	0,520	0,712	0,370

These parametres are a conservative approach. The upper limit can be set taking into consideration the utilisation figures, which have been achieved when individual utilisation factors were restricted by bottlenecks in the mine system. In these cases a high level of the other utilisation figures was a neccessity.

p 2	s 2	t 2	l 2	u 2
0,010	0,800	0,550	0,750	0,413

The application of standard figures would result in the following utilisation:

p 3	s 3	t 3	l 3	u 3
0,010	0,750	0,566	0,800	0,453

The total utilisations u1 and u2 result in the yearly effective capacities computed in *[ATT 17 - 22 / 25]* . The majority of the small spare excavators in the LCPA has not been taken into consideration in this calculation. A comparison of these figures with the requirements of total excavation *[ATT 12 - 3]* shows, that PPC s excavator capacity is sufficient in any case.

In our present production schedules the yearly effective capacities for the least theoretical capacity at the lower total utilisation u1 have been assumed. The present operational constraints *[SCT 1.3.2]* are assumed to be removed by the year 2010. These activities can be expedited whenever a higher utilisation is necessary at an earlier point of time.

To achieve a higher level of utilisation at an earlier point of time than assumed for our production schedules, is an option to reduce the costs of PPC s lignite presented later in this report *[SCT5]* .

1.4 The Transportation System in PPC s Mines

As mentioned before *[SCT 1.3]* The utilisation of the excavators depends on the layout of the transportation system in the mines.

Information about this matter has been collected in *[ATT 18]* :

Belt wagons are employed, to increase the reach of the excavators *[ATT 18 - 1]*. The theoretical capacity of the belt wagon should be 110 % of the theoretical excavator capacity. This guideline has not been observed in the past in any case.

In the attachments *[ATT 18 - 2 / 13]* the theoretical capacicity of the beltconveyors in PPC s mines has been calculated according to *[SCT 7.3 - 17 - 0]*.As a standard figure the theoretical capacity of the conveyor system should be 110 % of the theoretical excavator capacity. We found deviations from this guideline in both directions. In the Thalis Symphonia project proposals for the standardisation of the conveyor system have been presented. We did not carry out detailed own investigations in this field.

The employment of Spreaders is presented in *[ATT 18 - 14]*. As a guideline the theoretical capacity of the receivers in the system should be 120 % of the theoretical caapacity of the donors. In cases where the theoretical spreader capacity is not sufficient, an adjustment of the belt speed is the appropriate remedy measure. The standard belt speed for Rheinbraun s new spreaders is

7,5 [m / s].

In special cases, where not only a higher theoretical capacity but also an increased reach of the spreader was important, a belt velocity up to

15 [m / s]

has already been applied. We have not investigated this matter in detail, because there are proposals by the Thalis Symphonia project in this context.

The stockpiles are an essential element of the lignite handling systems of the mines. They equalise varialtions of the lignite supply and the lignite demand (Buffer function). Additionally they equalise variations of the lignite quality (Blending function). The stockpile volumes have been comprised in *[ATT 18 - 15]*.

At present the belt conveyor system and the receivers are restricting the level of utilisation of the excavators (Missing receivers, lack of theoretical capacity, lack of drive power). The removal of these operational constraints is a precondition for the achievemant of the level of utilisation proposed by the Masterplan Team.

1.5 The Auxiliary Equipment

The requirements of auxiliary equipment have been investigated in the Thalis Symphonia Project.

A status report referring to the auxiliary equipment has been presented by the Thalis Symphonia Project *[SCT 7.3 - 14 - Page C 77]*.

The demand of auxiliary equipment for the year 1995 has been determined in the phase II of the Thalis Symphonia project *[SCT 7.3 - 15 - 0]*.

We have adopted the requirements of auxiliary equipment, presented in this proposal for the year 1995.

These figures have been adjusted for the following years until 2020 according to the development of the mines until then.

Additional own investigations of this matter have not been executed.

1.6 The Personnel Requirements

A similar situation can be stated referring to the personnel

A status report referring to the personnel has been presented in the Thalis Symphonia project *[SCT 7.3 - 14 - Page A 23]* .

In July 1994 several scenaria for the future demand of personnel have been issued by the Thalis Symphonia Project *[SCT 7.3 - 16 - 0]* ..

We have adopted the Thalis Assessment for the year 1995 as the basis for the future personnel requirements.These figures have been adjusted for the years until 2020 according to the evolution of the mines until then.

Additional own investigations referring to the personnell requirements have not been executed.

1.7 Actual Information referring to Costs

As the basis for the comparison of our cost calculation results actual cost data are required.

The following PPC reports are available:

Public Power Corporation, General Directory of Economics, Directory of Economical Functions: Total Cost of Operation of the Corporation 1991.1992 & 1993

The corresponding report for the year 1994 will be issued later.

According to a statement of RE s cost accounting expert the comparison of the TMMP cost calculation results with the actual figures presents a problem. It requires a detailed analysis of the calculation algorithms. The discussion of these problems between RE s expert and PPC s representatives resulted in the decision, to calculate the so called levelised unit costs.

1.8 Conclusions: Data Collection

The data basis for the preparation of the TMMP, which has been collected in this first section of this report is to be judged below.

The following statements are essential in this context:

The lignite demand of the power stations cannot be determined sufficiently accurately at present:

The remaining lignite reserves in PPC s mines are not sufficient for the operation of all lignite fired units until 2020. The older power station units are to be closed down earlier than assumed up to now.

This calls for a review of the operation schedule of the base load units in the Mainland Grid of Greece. The future evolution of the utilisation will be different from the present assumptions.

The actual utilisation figures for the lignite fired base load units indicate, that the future utilisation of these units may have been underestimated

At present the lignite, supplied by PPC s opencast mines to the lignite fired base load units in the LCPA is blended with other fuels (E.g. xylite and imported black coal). According to PPC s decision the TMMP was to be prepared under the assumption, that no other fuels as such are contributing to the fuel demand of the power stations.

It could, however, be a favourable option, not to abandon the present method, to upgrade the lignite supply for the power stations with small quantities of other fuels as e.g. dry PPC lignite. This results to considerably increasing reserves of calorific energy in PPC`s mines and to decreasing mining ratios.

Additionally the geological, hydrological and geotechnical data base is not sufficiently accurate for long term planning purposes. The present reserve calculations cannot be regarded as final:

In the case of the mines supplying lignite to the Ptolemais and Kardia power stations the introduction of lignite drying is expected to result in considerably increasing reserves and lower mining ratios.

We learnt, that the Amyntaion power station can be operated at full load with a fuel of about 850 [kcal / kg] instead of 950 [kcal / kg]. This reduced calorific value is expected to result in a higher exploitable reserve as well..

Another area of concern are the quality parametres of the strata without analysis. The calorific value of these materials, which are blended with the pure lignite in the form of dilutions, could be higher than assumed up to now. This will again result in higher reserves of exploitable lignite and lower exploitation ratios.

The utilisation of PPC s Main Mine Eqipment is the third field of discussions. Aside of certain bottlenecks (Theoretical capacity of the beltconveyor system, drive power requirements, missing receivers) The overcapacity in PPC s mines is an important operational constraint. Even the upper limit for the utilisation parameters proposed by the Masterplan Team has already been achieved and exceeded in the past, because in these cases there was no overcapacity. As long as the the present overcapacity is kept in operation in the other mines, this proposal will, however, not be achieved.

PPC s approach, to reduce the mine capacity only after the equipment has achieved the level of utilisation proposed by the Masterplan Team cannot prove the possibility of capacity reductions.

A review of the present concept of development will become necessary after new information referring to the lignite demand, the remaining reserves is available.

2 Alternative Solutions

In the second section of this report the conceptual mine planning until 2020 is to be described as a basis for the final cost calculation. Additionally the remaining period of operation until exhaustion of the lignite reserves has been estimated

In order to be on the safe side the concepts of development for the LCPA and the LCM were to be presented according to the guideline, that no „other fuels" are to be supplied to the power stations.

The Subjects to be dealt with in context with the concept of development are

- Conceptual alternatives including the
- the concept of reclamation,
- the production schedules,

The scope of work stipulates the design of alternative concepts. The best alternative is then to be selected for a more detailed planning. This procedure does, however not apply in any case. Many of the alternative conepts described below, could only be designed after having already calculated production schedules. this is the reason, why these alternatives are presented as suggestions for the future planning work.

2.1 Conceptual Alternatives

In the scope of work the design of a concept of development for the LCPA is stipulated. for the LCM the present concept of development is only to be reviewed.

2.1.1 Conceptual Alternatives - LCPA

The concept of development for the LCPA includes conceptual alternatives for the following mines:

- Sector 6 & West Field South,
- South Field,
- Komanos
- North Field
- West Field North
- Amyntaion

2.1.1.1 Conceptual Alternatives Sector 6 & Westfield South

For the design of the concept of development for the Sector 6 & Westfield South the following subjects to be taken into consideration:

- The method of development for the Westfield South.
- The limits of the mine area.
- The relocation of the belt distribution point.

2.1.1.1.1 The Methods of Development for the Westfield South

In principle the Westfield South can either be developed as a new mine or the Sector 6 and the Westfield South can be exploited as one mine. In this case the road Kozani / Ptolemais, the railway line from Kozani to Ptolemais and the Soulou river, which separate these two mining areas, are to be relocated prior to the exploitation of the West Field South.

If the West Field South is exploited as a separate mine, only restricted reserves are exploitable *[ATT 19 - 1]*. Major fractions of the reserves are blocked in the safety pillar for the Soulou river (75 Mt). Due to the present status of the geotechnical investigations a safety distanceof 925 m between the power station and the excavation front of the West Field South is to be maintained. According to these restrictions only 30 [Mt] can be exploited. These reserves are not sufficient for the development of a new mine. The road and railway line Kozani / Ptolemais and the Soulou creek are to be relocated. The Sector 6 and the West Field South mine areas are to be mined as one mine.

For the aforementioned relocation activities the alternatives in attachment *[ATT 19 - 2]* have been taken into account. The Soulou creek is to be relocated on the internal dumps of the South Field and the Sector 6 in any case. A decision about the relocation of the road on an alignment western of the two parts of the West Field has already been made. We learnt, that this decision cannot be reviewed. The railway line however, could be relocated on the inpit dumps of the South Field and the Sector 6 (Alternative A). A second proposal has been presented by PPC. This allignment follows the western perimeter of the West Field South until it reaches its northern end. Then it turns to the east and crosses the gap between the northen and the southern part of the West Field (Alternative B).

A comparison of both alternatives is presented in attachment *[ATT 19 - 3]*. It shows the criteria, to be taken into account for the selection of the best alternative.

Line 1, The Length of the Railway Track, to be relocated:

There is almost no difference of the length of both alignments. Both alternatives are equal referring to the length of the railway track to be relocated.

Line 2, Duration of the Interruption of the old Railway Line:

In the alternative A the new alignment for the railway line crosses the old Soulou river and the old railway line. As a consequence of this fact the new railway line must either cross the old one on a bridge or OSE must agree to interrupt the operation of the railway line for a longer period of time, which is sufficient to close a gap in the new alignment immediately before the old alignment is to be excavated by the Sector Six. Both possibilities do not look very favourable.

In the Alternative B the new alignment is only to be connected to the remaining old railway line in a short action prior to the interruption of the old railway line by the Sector Six.
The Alternative B is more favourable from this aspect.

Line 3, Lignite Losses:

In Alternative A we assumed a distance of 85 [m] between the axis of the road and the railway line and a distance of 200 [m] between the axis of the railway line and the upper crest of the perimeter slope of the West Field South. These assumptions result to only small lignite losses due to the railway relocation (about 1,5 [Mt]). If OSE does not agree to the above mentioned safety distances, the lignite losses for alternative A are to be recalculated.

The safety distance of 200m between the railway alignment and the upper crest of the perimeter slope of the West Field North is a standard distance, which is to be proven by a detailed geotechnical investigation, that cannot be carried out at present due to the missing detailed geological information (correlation of the strata, tectonics)

The Alternative B does not result to lignite losses.

At present the alternative B is only slightly favourable referring to the lignite losses. Corresponding to the results of the discussions with OSE or to the results of the geotechnical investigations mentioned above the present situation can be changed considerably and the lignite losses, resulting to alternative A can increase by far. A second relocation of the railway line and the road aside of the railway in a western direction in order to avoid the above mentioned lignite losses is technically complicated due to the topography west of the presently planned alignments. The expenses for this measure may also not be justified, as the achievable additional reserves are little.

Line 4, Subsidence Effects, Slope Deformations:

In alternative A only negligible subsidence effects are to be expected in areas, where the alignment calls for fill activities, the maximum height of fill is about 12 [m].

There are however slope deformations due to the dewatering of the mine area and later on due to the operation of the excavators and spreaders to be taken into account. These slope deformations result to railway maintenance requirements, as long as the West Field South is operating close to the railway alignment.

In the alternative B about 4,3 [km] out of the total length of 13 [km] is located on the internal dump of the South Field (Dump height: up to 190m). 2,3 [km] of the alignment cross the internal dump of the Sector 6, where the maximum height of the dump is about 20 [m]. As the subsidence decreases quickly as a function of the time, it is to be taken into account only for a restricted period of time (about 7 -10 years). About 80 - 90 % of the total subsidence take place during the first two years after completion of the dump surface. The time between the completion of the dump and the start up of the construction of the railway line is essential for the assessment of the subsidence effects. If this time is sufficiently long, considerably smaller subsidence effects are to be expected after commissioning of the new railway line. This precondition can be ensured by an appropriate steering of the Sector 6 Mine and the South Field.

We regard the alternative A more favourable referring to the subsidence and slope deformation effects.

Line 5, Geotechnical Risks:

In the Alternative A the excavation front of the West Field South respectively the West Field North followed by the dump front will move along a large section of the railway alignment for a long period of time. At present we have assumed a safety distance of 200 [m] in order to avoid geotechnical risks. This safety distance is not yet supported by an appropriate geotechnical investigation. As the geological and hydrological database for such investigations is not sufficient (the deposits are not correlated ; the inclination of the strata and the position of faults is unknown), some time is required to improve this situation. Accordingly geotechnical risks cannot be excluded in Alternative A at present.

In Alternative B we have dump slopes on both sides of the railway alignment. These slopes will move to positions with increasing distance from the alignment continuously. Accordingly the geotechnical risk is minor compared to Alternative A from our point of view.

We regard the alternative B as more favourable referring to the geotechnical risks.

Line 6, Inclination of the Alignment:
In the alternative A an inclination of up to 1,5 % is to be applied in order to overcome the difference of elevations along the alignment.

In the alternative B the alignment is almost horizontal.

The operation of trains is easier on a track with small inclinations. Correspondingly we regard the alternative B to be the more favourable referring to the inclination of the alignment.

Line 7, Number of Curves:
Due to operational reasons we regard the alternative B as more favourable as this alignment has less curves.

Line 8, Cut & Fill Requirements:
The cut & fill requirements cannot be determined at present sufficiently accurately as the topographical information is not appropriate. The surface of the internal dump can be prepared as required by the mine. In this area we expect only negligible cut & fill requirements.

Conclusions:
At present PPC and OSE prefer the Alternative A. For OSE the subsidence effects in the case of Alternative B are the decisive reason in this context.

PPC prefers alternative A as in this case the mine development does not depend on the relocation of the railway line *[SCT 7.3 -18 - 0]*. It still depends, however, on the relocation of the Soulou creek.

The geotechnical risks for the railway line and the road west of the two parts of the Westfield and the railway line between the two parts of the West Field are to be checked. Especially the western perimeter of the two parts of the West Field is now characterised as a geotechnically risky area *[SCT 1.2.2 & 1.2.3]*.

2.1.1.1.2 The Limits of the Mine Area

At present the sector 4 of the sector 6 mine (the area east of the Kardia power station) has been transferred from the South Field mining area to the sector 6 mine for various reasons.

The acquisition of the land and the availability of belt conveyor material are areas of concern. Both problems can be solved, if there is a possibility to postpone the exploitation of the sector 4 by about two years. A possibility, to do so will be shown in context with the conceptual alternatives for the South Field.

The most important reason for the selection of the present solution was, however, the necessity, to complete the alignment for the relocation of the Soulou creek prior to the exhaustion of the Sector 6 reserves and the start up of the exploitation of the West Field South, which calls for the interruption of the present river bed of the Soulou.

If the reserves of the Sector 6 & West Field South are increased by blending the lignite with dry lignite, the exploitation of the Sector 6 takes considerably more time. In that case the option should be investigated, to exploit the sector 4 of the Sector 6 mine as a part of the South Field.

The Sector 6 would then most likely be in the position be in the position, to ensure the lignite supply to the Kardia power station without any support from the South Field. This results in essential advantages for the operation of the South Field.

2.1.1.1.3 The Relocation of the Belt Distribution Point

The exploitation of the Sector 6 and the West Field South as one mine calls for a relocation of the present belt distribution point, in order to reduce the distance of lignite transportation to the Kardia power station, and in order to simplify the mining sequence for the exploitation of both areas.

The present belt distribution point sits in the middle of the Sector 6 Area. The relocation to a position at the northern end of the Sector 4 in the Sector 6 & West Field South mine is described in three phases in the attachments *[ATT 19 - 4 / 6]*.

The basic idea for this proposal is, to remove the old distribution point as quickly as possible, when the excavation front of Sector 6 is approaching the end of sector 5, because the old distribution point is hampering the development of the mine after the relocation.

This target can be achieved as the new distribution point will consist of eight shunting heads whereas the existing distribution point includes only five shunting heads. There is, however one additional excavator to commence operation in the Sector 6 mine prior to the relocation of the belt distribution point. It is suggested to operate this excavator in the area of the sectors 6 and 7 of the Sector 6 mine in order to expedite the removal of the external dump of Kardia.

The three additional shunting heads for the new Sector 6 distribution point can be erected after the excavation front of the Sector 6 mine has exposed its location.

Another three shunting heads with two transfer points only are assumed to be available after the dismantling of the old Kardia and the North Field distribution points. These three shunting heads form a temporary distribution point for the benches four, five and six during the exploitation of the sector four of the sector 6 mine.

Attachment *[ATT 19 - 4]* shows the mine position of the sector 6 mine close to the end of the year 2009. The overburden excavation in the sector four of the Sector 6 Mine has been completed. The three new and the three temporary shunting heads have been erected, including one overburden excavator, which is temporarily not connected to the belt distribution point. It is now possible to quickly remove the old distribution point and start the further development of the Sector 6 mine in an anti-clockwise slewing movement around the new distribution point.

In attachment *[ATT 19 - 5]* , the mine position after the completion of the activities described above at the beginning of the year 2010 is shown.

The mine position about 1,5 years later is shown in attachment *[ATT 19 - 6]*.

In order to prepare the alignment of the Soulou creek as soon as possible, it is essential, to exploit the lignite in the sector four of the Sector 6 mine as indicated with two conveyor sections per bench.

The major fraction of the alignment for the Soulou relocation is prepared by the inpit dump of the South Field, allowing for sufficient subsidence time.

As far as this alignment is located in the area of the sector four of the Sector 6 mine , this does, however, not apply. As a remedy measure a provisional relocation of the Soulou creek in western direction to the sector eight of the mine can be taken into consideration.

2.1.1.1.4 The Requirements of Equipment Capacity

Our present masscalculation for the Sector 6 & West Field South results in a high mining ratio after the first sectors. A recent review of this masscalculation did not result in a considerably improved situation *[ATT 15 -8]* .

This high mining ratio requires additional excavator capacity until the reserves in the safety pillar of the Kardia power station are exploited, where the mining ratio is considerably lower, because this sector has been evaluated aiming to supply lignite with the lower calorific value specified for the Agios Dimitrios power station. During the exploitation of these reserves rhe West Field South and the Southfield supply the lignite demand of The Agios Dimitrios power station together.

There are two options to adjust the mine capacity of the Sector 6 & West Field South mine as required:

- The first of option is the employment of a waste excavator from the Amyntaion mine together with one of the spreaders, after the relocation of the belt distribution point of the Sector 6.
- A second option is, to borrow an excavator plus spreader from the South Field as soon as possible for a period of time until the belt distribution point in the South Field will have been relocated. At that point of time the mining ratio in the South Field starts to increase and the mine capacity of the South Field is to increase correspondingly. This proposal has been presented in August 1995.

The ongoing discussion of this matter has not yet resulted in a decision.

There is no agreement about the employment of the Amyntaion equipment in the Sector 6. Very conservatively it has been proposed by the LCPA, to post pone it, until the Amyntaion mine has achieved the level of utilisation proposed by the Masterplan Team.T

This will not apply prior to having reduced the mine capacity in the Amyntaion mine. The excavator will never be available for the Sector 6if this approach applies.

The second option is judged similarly by the Masterplan Team.

Although there a considerable overcapacity in the Southfield as in the Amyntaion mine, previous proposals, to employ a Southfield excavator plus spreader for the exploitation of the expit dump N° 2 have been rejected in the past.

Our present proposal, which has been presented in July 1995 as an alternative for the employment of the aforementioned Amyntaion equipment has not yet been answered.

LCPA-proposals to use a contractor or to buy new equipment instead of exchanging equipment between the mines are not acceptable for the Masterplan Team according to techno- commercial considerations.

Due to the Situation described above a final concept for the mine equipment of the Sector 6 & West Field South cannot be presented at the time being.

For the present production schedule of the Sector 6 & West Field South the employment of the Amytaion equipment has been assumed. It was our objective in this case, to avoid an expansion of the Sector 6 belt distribution point prior to ist relocation.

As a consequence the lignite transportation from the Southfield to the Kardia power staion increases during a period of time, when this is a problem for the South Field. Additionally the exploitation of the safety pillar of the Kardia power station commences too late. At that point of time the Southfield reserves are already almost exhausted and the major fraction of the Agios Dimitrios demand is to be supplied by the West Field South.

To borrow equipment from the Southfield until the the increasing mining ratio in the Southfield is apparently the more favourable solution. it is suggested to further investigate this option.

2.1.1.2 Conceptual Alternatives South Field

The concepts of development for the South Field and for the Sector 6 & West Field Sout mine depend on each other

The conceptional targets for the Sector 6 Mine call for a considerable lignite supply from the South Field to the Kardia Power Station.

At the same time the lignite release capacity of the South Field is restricted by the necessary hardrock removal, as described above. The hardrock, to be removed until the relocation of the belt distribution point of the South Field can be handled just in time. The lignite release figures, which are on schedule at present, must not be exceeded.

There is a possibility, to reduce the South Field supply of lignite to the Kardia power station.This would result to a much more flexible schedule of development for the South Field.

The masscalculation and the production schedule for the South Field, Variant 5 has not yet been adjusted according to the modification of the exploitation of the Sectors 5 & 6 described above.

As in the case of the Sector 6 a detailed analysis of the relocation of the distribution Point of the South Field is recommended as soon as this activity is within the reach of the mid term planning for the South Field. This relocation starts with the exposure of the bottom of the mine in the area of the new belt distribution point about in 2005. We recommend to start with the preparation of a benchwise mid term planning for the South Field now.

2.2 Conclusions

We identify three essential reasons for a review of the conceptual planning for PPC s mines.

These reasons are:

- The lignite demand assumed for this analysis has most likely been underestimated. The future utilisation as assumed by PPC has been higher during 1995 than assumed, this is a favourable development referring to the costs of the lignite based generation of electricity. On the other hand it requires a review of the TMMP in the not too far future.
- The remaining reserves have been assessed conservatively, due to the status of the deposit exploration (Especially the missing quality parametres for the intercalations).
- The lignite demand and the mining ratio (Reserves as input for the ratio) result in the requirements of total excavation, which must correspond to the main mine capacity. Our present assessment of the future utilisaton of PPC s equipment is again a conservative approach. The acceptance of our proposals is an important target.

Actual developments in these three areas can result in the necessity to review the basic concept of development for PPC s mines in the LCPA and in the LCM within some years.

2.3 The Concept of Reclamation

The second item to be dealt with under the headline "Conceptual Mine Planning" is the concept of reclamation.

According to our experience it is essential, to include the final reclamation of the mined out areas as far as possible in the operation of the Main Mine Equipment, in order to carry out the reclamation and recultivation as cheap as possible.

The waste layers, which are most suitable for the future recultivation are to be mined selectively and to be dumped selectively on the dump surface. This principle cannot be applied strictly in PPC s mines, because each spreader serves normally more then one excavator. The chemical composition of the waste strata allows, however, to use blended waste for the preparation of dump surfaces. This must not necessarily be topsoil only. Waste strata from the deeper part of the excavation site can be dumped on the surface of the future recultivation areas as well *[SCT 4.6.1.3]*.

The preparation of the inpit- and expit-dump surfaces in the LCPA and in the LCM for the future recultivation with the Main Mine equipment is to be described below.

2.3.1 The Preparation of the Dump Surfaces in the LCPA

In the LCPA the last decades of mine operation have left behind a large unreclaimed and unrecultivated area.

This situation makes the reclamation even more important than normally. The situation is, however not only characterised by the aforementioned backlog of the reclamation and re-cultivation.

Additionally we are to take into account a considerable demand of expit dumping volume.

In the Ptolemais area and in Amyntaion the following quantities are still to be dumped externally:

LCPA - West Field North	189,0 [Mm³]
LCPA - Sector 6 & West Field South	767,1 [Mm³]
LCPA - South Field	711,7 [Mm³]
LCPA - Ptolemais Area (Acc. Figures)	1 667,8 [Mm³]
LCPA - Amyntaion	939,3 [Mm³]

The aforementioned unreclaimed area, left behind by the Ptolemais mines is the appropriate expit dump area for the expit dumps of the South Field (Together with the present expit dump of the South Field), the Sector 6 & West Field South and for the West Field North, because the Ptolemais Lignite Basin is limited by mountain areas, which are not favourable for expit dumping.

The preparation of the future reclamation area in the centre of the Ptolemais area is described in *[ATT 21 - 1 / 3]*.

In Amyntaion the present expit dump is filled up to its final volume mentioned above. The reclamation area. The Reclamation area on this expit dump and on the inpit dump of Amyntaion is shown in *[ATT 21 - 1 / 3]*.

2.4 Production Scheduling for the individual Mines

The sector wise masscalculation results, the conceptual considerations described above and the lignite demand of the power stations are the base for the preparation of the production schedules.

A graphical representation of the production schedules and the relations between the schedules for the individual mines are to be described and the production schedule for each mine is to be presented. Conclusions and recommendations referring to the production schedules are to be presented.

Accordingly there are three subjects to be dealt with:

1. General matters in context with the production schedules.
2. Production schedules for the individual mines.
3. Conclusions and Recommendations

2.4.1 General Matters in Context with the Production Schedules

The general matters to be described in this section are:

1. The graphical representation of masscalculation results an production schedule,
2. The integration of the individual production schedules,

2.4.1.1 Graphical Representation of Masscalculation Results & Production Schedule

The graphical representation of masscalculation results and production schedule to be demonstrated below is a tool for planning and mine operation at the same time. It allows, to judge mine positions and to adjust the production schedule taking into account all restrictions to be observed.

[ATT 22 - 1 & 2]:

An example for the results of a sector wise masscalculation between excavation slope systems and the corresponding dump slope systems with minimum bench width is shown in the attachments mentioned in the headline. These sector slope systems are normally not representing mine positions. The exceptions from this rule will be described below.

A graphical representation of these masscalculations is developed step by step based on these masscalculation results.

[ATT 22 - 3]:
The attachment shows a system of coordinates. On the x-axis the accumulated lignite content at the end of the excavation sectors 0 - 12 in [Mt] is shown. On the y-axis several volumes are to be shown. Positive figures represent the excavation site of the mine. Negative Figures belong to the dump of the mine. To allow for an easy orientation, the accumulated lignite contents of the Sectors 0 - 12 are shown as vertical lines. The corresponding accumulated volumes mentioned above will be shown as dots on these vertical lines. The first of these volumes is the accumulated lignite volume ("Lign. Vol") at the end of the sectors 0 - 12 in [Mm³]. The corresponding lignite weight has been converted to the volume by dividing it through the density of the lignite.

[ATT 22 - 4]:
Here the accumulated total excavation figures ("T.E.Min.") resulting to the masscalculation have been added. Between "T.E.Min." and "Lign." the total waste excavation can be determined.

[ATT 22 - 5]:
The accumulated total excavation figures ("T.E.Min."), are then converted to the minimum dump volume requirements ("D.V.Min.").

The minimum waste excavation ("T.E.Min."-"Lign.") is multiplied with the remaining swell. In all TMMP masscalculations a factor of

1,05 [--]

[ATT 22 - 2] has been applied for this purpose. Recent investigations in Rheinbraun s mines indicate, that the remaining swell may be much smaller. So far we chose a conservative approach.

The dump volume is further increased by the deposition of ash (and possibly other materials to be dumped in the mine). The accurate amount of ash to be dumped in each mine is known after the preparation of the production schedules. During the masscalculation phase, the lignite content of each mine has been converted to the corresponding ash weight. This ash weight has been converted to the corresponding dump volume by multiplying it with the factor

0,9 [m³ / t]

[ATT 22 - 2]. This factor has been determined by long-term observations of the ash dumps in Rheinbraun s former Frimmersdorf opencast mine.

[ATT 22 - 6]:

The dump space inventory on the inpit dump ("Dmp Invent.") of the mine is then determined by deducting the accumulated volume of the the inpit dump sectors from the minimum dump volume requirements ("D.V.Min."). The minimum of this graph (" Dmp Invent.") is the minimum expit dump volume.

The approach chosen for this calculation is: The accumulated inpit dump volume is to be filled up completely prior to expit dumping. Doing so, the expit dump volume is completely consumed in the so called criticalmine position (at the end of sector 11 in this case).

This expit dump volume is, however, available at any point of time prior to the end of the sector 11.

[ATT 22 - 7]:

On the base of this assumption we are now in the position, to determine the maximum possible dump volume ("D.V.Max.") by adding the accumulated volume of the inpit dump sectors to the known volume of the expit dump. The minimum dump volume ("D.V.Min") and the maximum dump volume ("D.V.Max") are equal at the end of sector 11, and they must be equal due to the algorithms applied. The mine has reached its so called critical position. The dump slope system corresponds to the sector slope at the end of the sector 11.

[ATT 22 - 8]:

The maximum dump volume ("D.V.Max") can now be converted to the maximum total excavation ("T.E.Max"). The ash component in the maximum dump volume is to be converted into the corresponding lignite volume and the waste is again converted to solid ground. The maximum total excavation ("T.E.Max") and the minimum total excavation ("T.E.Min") are also equal at the end of the sector 11, where the space inventory of the inpit dump ("invent.") passes its minimum. The mine has reached its critical position. The dump slope system and the excavation front correspond to the sector slope at the end of sector 11.

The maximum total excavation has been determined based on dump space considerations. There is, however, another restriction to be observed. The minimum total excavation ("T.E.Min") can only be exceeded by prestripping overburden. Correspondingly the difference between the minimum total excavation ("T.E.Min") and the maximum total excavation ("T.E.Max.") must not be more than the remaining accumulated overburden at the end of each of the sectors. By adding this figure the maximum prestripping possibilities can be determined. As long as the maximum total excavation is less than the the maximum prestripping possibilities the maximum of the total excavation represents the upper limit of the total excavation and vice versa.

According to the considerations and calculations the production schedule for an opencast mine with inpit dumping must be kept between the maximum total excavation (T. E. Max) and the minimum total excavation (T. E. Min).

Any production schedule within these limits is feasible. The calculated requirements of expit dumping volume will not be exceeded in this case.

If the production schedule touches the upper limit for the total excavation, the slope system on the dumping side corresponds to the sector slope design. The bench width is then equal to the minimum width assumed for the design of the dump sector slope. the excavation front is then flatter than the sector slope design.

If, however the production schedule touches the lower limit for the total excavation, The excavation slope system corresponds to the sector slope geometry, and the dump slope system is flatter than the sector slope design. In the critical mine position the excavation front and the dump slope system correspond to the sector slope design. only in this case the sector slopes can be used for the design of a mine position.

As we see it, this diagram is

- a tool for long term planning purposes. Alternative production schedules can easily be designed within the limits to be observed.
- Additionally it is provides the possibility to judge a mine position easily and quickly and remedy measures for problems referring to the production schedules can be considered on the basis of thei diagram. An actualised copy of this diagram should be made available for the technical management of each PPC mine regularly.

2.4.1.2 The Integration of the individual Production Schedules

The relations and restrictions to be observed for the design of the production schedule for a single mine have been described in the last section of this report. The design of the Masterplan for a mining area is, however more then the preparation of a production schedule for each mine. The operation of the mines in this area as a total is to be co-ordinated in order to achieve certain objectives, taking into account certain restrictions. An "integrated production schedule for the total mining area is to be designed. This is perhaps the most essential objective for a Masterplan.

The Amyntaion mine, the mines in the Ptolemais area and the LCM mines are to be discussed separately.

2.4.1.2.1 The Amyntaion Mine

According to their geographical position we regard the Amyntaion mine and the Amyntaion Power station as a separate unit which is not to be integrated into the Ptolemais system. Considerations referring to the lignite reserves and especially to the costs of lignite tansportation result to this conclusion.

2.4.1.2.2 The Ptolemais Mines

For the Ptolemais mines the following subjects are to be taken into account for the coordination of the operation of the mines in this area

- Investments for additional Main Mine Equipment
- How to achieve the highest possible Lignite Release
- The Preparation of the Alignment for the Relocation of The Soulou Creek
- The Lignite Reserves in the Safety Pillars of the Kardia, Liptol & Ptolemais Power stations

2.4.1.2.2.1 Investments for additional Main Mine Equipment:

The future requirements of equipment capacity depend on the evolution of the lignite demand and of the exploitation ratio. According to the evolution of these parameters a reduction of the necessary equipment capacity can be expected soon

In 1997 the fifth unit of the Agios Dimitrios power station is to commence operation. The lignite demand will then be increasing to its peak value.

According to the remaining lignite reserves the decommissioning of PPC s oldest lignite fired power station units is then to start soon. The lignite demand will then decrease again.

On the other hand a general upward trend of the exploitation ratio is to be expected.

Nevertheless increasing capacity reserves are to be expected, at the end of the Masterplan period (2020), as the total excavation requirements will begin to decrease in future due to the decreasing lignite demand.

In this situation it is our intention, to avoid investments for additional main mine equipment. The period for the utilisation of these investment is expected to be uneconomically short.

2.4.1.2.2.2 How to achieve the highest possible Lignite Release:

During the first years of the Masterplan period, when the lignite release requirementsare still increasing, it is essential to achieve the highest possible lignite release.

Whenever more than one mine contribute to the lignite supply of one power station, the achievable lignite release can be increased as follows:

Phase 1:
The achievable lignite release L [Mt / a] of a mine results to the accumulated excavator capacity Qeff [Mm^3 / a] and to the exploitation ratio r [Mm^3 / Mt].

$$L\ [Mt/a] = Q\ [Mm^3 / a] / r\ [Mm^3 / Mt]$$

As described in the previous section the exploitation ratio can be selected with in certain limits. If two mines are supplying lignite to the same consumer, it is to be checked in which mine the lower exploitation ratio can be achieved by the application of the possibility, to adjust the production schedule between the upper and the lower limit for the total excavation. based on this lowest possible exploitation ratio the mine is then to contribute the highest achievable lignite release.

At the same time the second supplier is to contribute only the difference between the demand of the consumer and the contribution of the first mine. 2.3.2. The Production Schedules for the individual Mines. its excavator capacity is to be employed as far as possible for the prestripping of overburden.

Doing so the remaining exploitation ratio is reduced as far as possible. The second mine is prepared for the time after the exhaustion of the reserves of the first mine.

Phase 2:
During the second phase after the exploitation of the reserves of the first mine the second mine, which has been prestripping overburden until then, is further on developed according to the strategy for the now exhausted first mine.

Its production schedule is adjusted in order to achieve the minimum achievable exploitation ratio. The second mine is now to release the maximum achievable quantity of lignite. The substitute mine is then to contribute only the difference between the demand of the consumer and the lignite release of the second mine. its excavator capacity is employed as far as possible for the prestripping of overburden.

2.4.1.2.2.3 The Preparation of the Alignment for the Relocation of The Soulou Creek

The quick development of the South Field and the delayed development of the Sector 6 correspond to the necessity, to prepare an alignment on the inpit dump of the South Field and on the inpit and expit dump of the Sector 6 mine. The cheapest, technically most favourable solution for the relocation of the Soulou creek is the relocation on the dumps of the sector 6 and the South Field. If this can be achieved just by steering the progress of the South Field and the Sector 6 appropriately another temporary solution -e. g. a provisional pipeline- should not be taken into consideration. It will result to evitable additional costs. During strong rainfalls such a pipeline may also be a serious, evitable risk.

2.4.1.2.2.4 The Lignite Reserves in the Safety Pillars Power Stations

The remaining reserves have been assigned to the power stations of the LCPA in order to reduce lignite transportations *[ATT 15 - 8]*.

The reserves for the Kardia power station include a quantity of lignite, which is located in the safety pillar of the Liptol and Ptolemais power stations. This quantity amounts to

27,636 [Mt], *[ATT 15 - 8, N° 1.4.1.2.]*

This lignite quantity can only be exploited after the decommissioning and demolition of the Kardia and Liptol power stations. In order to reduce the necessary lignite transportations, this lignite should be consumed by the Kardia Power station as far as possible. The transportation of this Lignite to the Agios Dimitrios power station should be avoided as far as possible.

The Liptol and Ptolemais Power stations must decommission a sufficiently long period of time earlier before the decommissioning of the Kardia power station. Otherwise there is no possibility, to transport the aforementioned quantity of lignite to the Kardia Power station.

A similar situation is to be observed in the case of the Agios Dimitrios Power station. The reserves assigned to this power station include the lignite in the safety pillar of the Kardia Power station.

363,031 [Mt], *[ATT 15 - 8, N° 1.4.2.2.]*

As The Liptol and Ptolemais power stations must decommission prior to the Kardia power station, and because the Kardia power station must decommission prior to the exploitation of the reserves in the Kardia safety pillar, the only remaining consumer for this lignite is then the Agios Dimitrios Power station. Accordingly the Agios Dimitrios Power station must continue, to operate longer than the Kardia power station.

These facts are to be taken into consideration for the design of the production schedules of the Ptolemais mines. They may even be a reason, to change the schedule of operation for the power stations in the Ptolemais area.

2.4.1.2.3 The Mines of the LCM

The "integrated production schedule" for the LCM mines has up to now been essentially influenced by assumptions referring to the distribution of the lignite quality in the Megalopolis lignite basin.

As described before in context with the calculation of the remaining reserves it is assumed, that the calorific value of the lignite in the Megalopolis Basin is higher in the South of the basin (Horemi mine) and tends to lower figures in the north of the basin (Marathoussa- & Kyparissia mines).

We regard this as an effect, which is related to an inappropriate evaluation procedure. According to our masscalculations the trend of the calorific value, assumed in the Goergen Study does not exist. As already found in other cases in the LCPA, The calorific value of the lignite can be set slightly atop of the specification of the power stations by selecting the cut off ash content for the masscalculations.

As a consequence of the different calorific values for the three mines in the LCM blending of the lignite released by these mines is strongly recommended in the Goergen Study. Only under this precondition the exploitation of the lignite with the minor calorific value in the Marathoussa mine and the Kyparissia mine is regarded as feasible.

This results to the operation of three mines in parallel. The consequence is the installation of a high equipment capacity, which cannot be operated on an acceptable level of utilisation in any case. The low utilisation and the economies of scale result to lignite costs, which are higher than necessary.

If the results of our masscalculation are adopted, the negative effects, resulting to the blending of the different lignite qualities could be removed after a transition period. In this transition period the exploitation of the two small mines was to be expedited and the lignite production was to be concentrated on the Horemi mine. This objective has partly been achieved in our present proposal for the LCM mines. The two small mines are exhausted in the year, when the first two units of Megalopolis A will be decommissioning (2022). The reserves of capacity in these mines are however still high. A review of the LCM production schedules aiming, to expedite the exploitation of Marathoussa in the second phase of the preparation of the TMMP is recommendable.

2.4.2 The Production Scheduling for the individual Mines

The general development of PPC s lignite mines in the LCPA and in the LCM is demonstrated in *[ATT 12 - 1 / 21]*.

PPC s lignite production reaches its peak value very soon in the future. According to the present operation schedule for the power stations a maximum lignite production of

65,6 [Mt / a]

will be achieved in the year 2000. Beyond that point of time the lignite production will be continuously decreasing *[ATT 12 - 1 & 2]*.

The decreasing lignite demand counterbalances the increasing exploitation ratio successfully. The maximum total excavation of

326,6 [Mm^3 / a]

is at present scheduled for the year 2011 *[ATT 12 - 3 & 4]*.. After that year the total excavation figures decrease continuously. The future adjustments of the production schedules for the individual mines are likely to further reduce this peak value. The objective of these adjustments is, to postpone the total excavation requirements, because the future lignite demand will be lower.

Our intention, not to spent investments for additional Main Mine Equipment is justified by these figure. The additional capacity, employed during the years 1995 - 2011, will soon become unemployed after the year 2011. We regard a period of utilisation as such as uneconomically short.

Our present production schedules, allow to achieve the production targets with minor difficulties. after the adjustments of these schedules (Follow up activity), these "difficulties" will be removed.

The exhaustion of the reserves in several mines during the Masterplan period of time until 2020 and the development of the substitute mines calls for the transportation of Main Mine Equipment. These transportations have been comprised in the form of a bar chart in attachment *[ATT 12 - 5 / 9]*.

The evolution of P=tolemais and the Amyntaion area in the LCPA and of the LCM mines is shown in mine positions for the years

1995, 2000, 2010 and 2020

for each of these areas *[ATT 12 - 10 / 21]*.

The basis for the production schedules described below is the lignite demand as tetermined in *[SCT 1.1]* , the lignite reserves and the mining ratio as calculated in *[SCT 1.2]* and the equipment utilisation as assumed in *[SCT 1.3]* . As mentioned before especially the lignite demand, the reserves and the mining ratio are to be reviewed. Corresponding to the results of this review the production schedules for PPC s lignite mines are to be reviewed as well.

2.4.2.1 Production Schedules for the LCPA Mines

In the LCPA the Amyntaion mine and the Mines in the Ptolemais area are geographically separated. In the Ptolemais area the North Field, the Komanos mine and the West Field North ensure the lignite supply for the Liptol and Ptolemais power stations. The Sector 6 & West Field South is the main supplier of lignite for the Kardia power station and the South Field is them ain supplier for the Agios Dimitrios power station.

2.4.2.1.1 LCPA - North Field Mine

In the attachments *[ATT 24 - 1 / 7]* the following items for the North Field are shown:

- Sector map excavation site,
- sector map dumping site,
- masscalculation results excavation and
- dumping site,
- graphical representation of the masscalculation results,
- production schedule,
- calculation of the excavator capacity.

The present long term concept of development for the West Field North is strongly influenced by the reserves and the mining ratio assumed up to now. These figures can, however, change considerably. If the supply of a small quantity of dry lignite prepared in PPC s Liptol facilities and a slighly lower ash content of the intercalations is assumed considerably higher reserves of lignite and a much lower mining ratio are the favourable consequence *[ATT 15 - 10]* . Actual figures in an investigation carried out in the LCPA indicate, that the ash content of

80 %

assumed in this calculation, might still be too high. The aforementioned LCPA investigation results in an ash content of the dilutions in the South field of

70 %.

The West Field North is one of the mines, where an investigation of the quality of the strata without analysis is especially important. As soon as the results of this investigation are available, it is suggested, to review the masscalculation and the production schedule for the West Field North *[SCT 1.2.4.1.3.3]* .

Until then the transportation of an excavator plus spreader from the Amyntaion mine to the West Field North is the only option, to increase the mine capacity in the West Field North as required. The planning of this measure must not be postponed.

2.4.2.1.4 LCPA - Sector 6 & West Field South Mine

In the attachments *[ATT 27 - 1 / 7]* the following items for the Sector 6 & West Field South mine are shown:

- Sector map excavation site,
- sector map dumping site,
- masscalculation results excavation and
- dumping site,
- graphical representation of the masscalculation results,
- production schedule,
- calculation of the excavator capacity.

Employment of the Excavator Capacity:

The production schedule proposed at present has been designed aiming to not expand the excavator capacity prior to the relocation of the belt distribution point of the Sector 6 mine, in order to keep this activity as simple as possible. In this case The sector 6 & West Field South capacity will be expanded by the employment of the Amyntaion excavator 211 after the relocation of the belt distribution point at the end of the exploitation of the sector 5 of the Sector 6 mine. Instead of an expansion of the Sector 6 capacity, it was our intention, to use the low ratio in the South Field for the external supply of lignite from the South Field to the Kardia power station.

This strategy results in two disadvantages in the South Field:

- During the exploitation of the Sectors 1 - 6 in the South Field the removal of hard rock material restricts the lignite release of the South Field. The external supplies for the Kardia power station raise the South Field lignite release close to its upper limit. an adjustment of the sequence of mining is necessary in order to overcome this problem *[SCT 2.4.2.1.5]*.

- The reserves in the sectors 10 until 12 (Safety pillar of the Kardia power station) are available too late for the supply of lignite to the Agios Dimitrios power station. The reserves of the South Field area already too small then. The major fraction of the Agios Dimitrios demand is to be supplied by the West Field South then, only a small rest is to be contributed by the South Field

Our present proposal can, however, be optimised.

The strategy to be applied for this optimisation is, to reduce the prestripping of waste and to increase the lignite release of the Sector 6 & West Field South mine correspondingly. This is especially important during the first phase of the mine operation, when the South Field is in charge for the external supply of lignite to the Kardia power station. The reduction of these external supply depends on the exploitation ratio applied during this phase. This ratio cannot be set independently on the second phase of the mine operation, when the West Field North will be in charge for the external supply of lignite to the Kardia power station.

The lower the ratio during phase 1 is set, the higher a ratio must be applied during the second phase, resulting in a correspondingly lower lignite release capacity of the sector 6 mine during this phase. The lignite release capacity of the Sector 6 mine and the capability of the West Field North, to supply additional lignite to the Kardia power station must, however correspond to the lignite demand of the Kardia power station during phase 2.

A rough investigation of these options indicates, that only a minor reduction of the external supply of lignite from the South Field to the Kardia power station (about 25 Mt) is possible during phase 1, and the reduction of the prestripping of waste during the second phase allows to reach the end of the sector 9 of the Sector 6 & West Field South mine only about 2 years earlier.

These changes do not remove the disadvantages of our present approach. Hence a completely different approach is to be investigated from our point of view. This different approach is, to increase the capacity of the Sector 6 & West Field South mine as soon as possible.

During phase 1 only the South Field can provide the equipment capacity for the Sector 6 mine. At present there is already a considerable capacity reserve in the South Field. If the capacity of the Sector 6 is increased, The present external supply from the South Field can be reduced and the capacity reserves of the South Field increase. The South Field will then be in the position, to lend an excavator and a spreader to the Sector 6.

The changes resulting to this approach compared to the present one can be described as follows:

- As the lignite release requirements of the South Field are lower, the capacity of the auxiliary equipment for the removal of hard material is likely not to be a bottleneck any more.
- Even the reduced excavator capacity of the South Field will be sufficient, to prestrip waste during the excavation of the South Field sectors 1 - 6.
- The higher lignite release of the Sector 6 mine during phase 1 will be expediting the exhaustion of the Sector 6 & West Field South reserves. The lignite reserves in the safety pillar of the Kardia power station will be available earlier, to be supplied to the Agios Dimitrios power station.
- The early employment of a South Field excavator plus spreader in the Sector 6 & West Field South mine could even result to the possibility, to not employ the Amyntaion excavator 211 in the Sector 6 mine, but to return it to the Amyntaion mine after the exploitation of the sector 3 of the West Field North. This option calls, however for a long term employment of the South Field excavator in the Sector 6 mine.

If the geotechnical investigations, referring to the layout of the safety pillar of the Kardia power station, result in a considerably smaller safety pillar, the early employment of additional excavator capacity in the Sector 6 mine will be the only measure, to avoid the exhaustion of the South Field reserves prior to the point of time, when the reserves in this safety pillar will become available for the supply to the Agios Dimitrios power station.

On the other hand the belt distribution point of the Sector 6 mine is to be expanded prior to its relocation.

We suggest to analyse the alternative production schedules for the Sector 6 (and the South Field) described above in the second phase of the preparation of the TMMP.

The Volume of the Expit Dump:

The Sector 6 & and West Field South mine will be reaching its critical mine position at the end of its Sector 11 *[ATT 31 - 04 & 05]*. The demand of expit dump volume until then will be 767,1 [Mm³].

The Transition from the External Dump to the Inpit Dump:

The expit dump volume, mentioned above, will consumed in the year 2010 (without inpit dumping).

We propose to start inpit dumping at the beginning of the year 2010, because the alignment for the Soulou relocation is to be prepared in time prior to the to the Soulou relocation in 2015 on the inpit dump of the Sector 6 mine in the area of the Sector 4 of the Sector 6 mine and at the eastern perimeter of the present mine opening.

This point of time corresponds to the relocation of the Sector 6 belt distribution point. The introduction of inpit dumping together with the relocation of the belt distribution point simplifies the access to the inpit dump of the Sector 6 and the belt system can be installed finally. No preliminary solution is necessary.

Aside of the West Field North the Sector 6 & West Field South as the main supplier of lignite for the Kardia power station is another case, where the introduction of the dry lignite concept is suggested. The reduction of the calorific value of the lignite, to be supplied to the Kardia power station is one of of the reasons for the increment of the reserves and the reduction of the mining ratio in *[ATT 15 - 10]* . The other reason for these favourable changes is the improved quality for the strata without analysis.

2.4.2.1.5 LCPA - South Field Mine

In the attachments *[ATT 28 - 1 / 7]* the following items for the South Field Mine are shown:

- Sector map excavation site,
- sector map dumping site,
- masscalculation results excavation and
- dumping site,
- graphical representation of the masscalculation results,
- production schedule,
- calculation of the excavator capacity.

3 Phase 3: Mine Operations

In this section of the report various subjects related to mine operation of LCPA- and LCM-mines are to be dealt with according to the Scope of work. The majority of these matters refer to the LCPA mines. In the LCM the concept of development applied at present is to be reviewed.

3.1 Lignite Centre Ptolemais Amyntaion (LCPA)

The scope of work includes the following subjects for the LCPA:

- Complete mining Study for the West Field
- Requirements of Main Mine Equipment for the Amyntaion mine
- Review and re design of the mining method for the South Field
- Removal of rock material in the South Field
- Options to increase the mine capacity in the other LCPA mines
- Excavation works by contractor
- Safety of lignite supply (Interlinking transport system, reserve fields)
- Requirements of additional main mine equipment.
- Production schedules.

3.1.1 Mining Study for the West Field (Northern and Southern Part)

The detailed study for both parts of the West Field includes the following subjects.

- Excavation
- Spoils Dump
- Electro- Mechanical Equipment
- Earth Moving and Civil lEngineering project

3.1.1.1 Excavation Site West Field North & South

For the excavation site of the two parts of the West Field the following subjects are to be dealt with:

- The method of mine development,
- the handling of hard layers,
- the sequence of mining,
- the design of benches (1.5000),
- the design [illegible] mine positions,
- geotechnical investigations,
- hydro-geology and hydrology studies.

<u>3.1.1.1.1 The Method of Mine Development</u>

The Method of mine development for both parts of the West Field has already been described before

In the West Field South there is the possibility to avoid the development of a new mine *[SCT 2.1.1.1]*. After the relocation of the road and the railway line Kozani /Ptolemais and of the Soulou creek, which are at present located between the Sector 6 and the West Field South, the excavation front of the Sector 6 will be moving into the West Field South without the necessity, to develop a new mine. This is essential because otherwise the exploitable reserves of the Westfield South would be reduced by far, because the safety pillar of the Soulou creek would be blocking considerable lignite reserves.

The West Field South cannot be developed by continuation of the excavation of an existing mine. Due to the reasons described in *[SCT 2.1.1.4]* the location for the boxcut has been selected in parallel to the present alignment of the Soulou creek at the southern end of the West Field North.

While the transition of the excavation front of the Sector 6 mine is scheduled to take place around the year 2015, the development of the West Field North is urgent. The present main suppliers of lignite for the Ptolemais and Liptol Power stations are the North Field and the Komanos Mine. The remaining reserves of these mines are already close to their exhaustion. In this context a decision about the exploitation of the reserves under the expit dump N°2 is still pending.

In the LCPA there are intentions to replace these reserves by the lignite reserves of the so called AOK-Extension. The Masterplan Team has calculated much smaller reserves for this area compared to the LCPA. These smaller reserves are already included into our production schedule. As long as the complete masscalculation of the LCPA is not available (Quantities, complete criteria of evaluation, complete quality data) we suggest not to rely on the higher reserves presented by the LCPA *[SCT 2.1.1.3.1]*.

<u>3.1.1.1.2 The Handling of hard Layers</u>

The quantities of hard material, to be expected in both parts of the West Field can up to now be roughly assessed only.

The reasons for this unfavourable situation have been described in *[SCT 1.2.1.2]*. The status of the geological interpretation of the deposit is not sufficiently advanced for this purpose. Accordingly we had to make rough assumptions about the quantities of hard material.

A general description of the methods of hardrock removal is presented in *[SCT 4.4]* of this report.

3.1.1.1.3 The Sequence of Mining

The sequence of mining for both parts of the West Field is described in *[SCT 2.3.2.1.4 & 2.3.2.1.5]* .

3.1.1.1.4 The Bench Design

The Scope of work calls for the design of benches (Scale 1:5000) for both parts of the West Field.

In this context some basic considerations referring to benchwise mine planning are to be presented.

The bench elevations are an essential tool for the steering of an opencast mine. The performance of the main mine equipment can be assessed with reasonable accuracy only for long term planning purposes. During the periods of time, applied for mid- and short term planning, the performance of the equipment varies inevitably within limits, which increase, as the period of time, taken into account decreases.

The bench design must fulfill the following requirements:

The quantities between the benches must be adjusted to the capacity of the machine on the bench,

the accumulated bench quantities must correspond to the procuction targets of the long term planning, in order to fulfill the lignite release requirements with sufficient mine flexibility and sufficient safety of supply. At the same time the production schedule must be kept well between the upper and lower limits for the total excavation at any time *[SCT 2.3.1.1]*.

This can only be achieved by an iterative procedure. The bench elevations are varied, until the quantities on the benches correspond to the capacity of the equipment and until the accumulated mine production for each year corresponds to the targets, set in the long term planning between the upper or lower limit for the total excavation.

According to these considerations benches are normally not designed for the total life span of an opencast mine. The bench elevations, which have been determined as described above are to be corrected regularly, because the long term performance of the equipment is inevitaqbly different from the mid and short term utilisation of the equipment.

Additionally the objective of the long term planning is normally, to select the optimum mining alternative. It is, however much to time consuming and expensive, to analyse the required number of alternatives benchwise. It is more appropriate to accept a certain loss of planning accuracy. which is related to the analysis without benches and to achieve a higher level of accuracy by the investigation of a sufficient number of alternatives.

These considerations must be taken into account in context with our bench design for both parts of the West Field. It does not fulfill the requirements described above. it is just the starting point for the future adjustments of the bench elevations during the mid term planning for the West Field. Certain differences between the quantities of the calculation without benches or with „benches" are inevitable.

The bench plans for the two parts of the West Field have been listed in *[SCT 7.2.1.3 & 7.2.1.5]* . Up to now these bench plans (1 . 5000, as stipulated in the contract) are not available. This is a pending matter.

3.1.1.1.5 Mine Positions West Field North & South

The scope of work calls for mine positions every two years for the first ten years of operation and every five years for the remaining mine life. These mine positions have been listed in *[SCT 7.2.1.3 & 7.2.1.5]*

3.1.1.1.6 The Belt Conveyor System

The mine positions mentioned in *[SCT 3.1.1.1.5]* include the belt conveyor sytem.

3.1.1.1.7 Bench Wise Masscalculations

For both parts of the West Field bench- and sector wise masscalculations are to be carried out.

The addition of our first bench wise masscalculations for the West Field South did not result in the quantities without benches. After having replaced the algorithm for the assignment of block thicknesses to the corner points of the masscalculation grid consistent results are achieved *[SCT 1.2.4.1.1]*.

Our masscalculations without benches have been carried out taking into account the so called economical bottom. For the bench wise masscalculations the economical bottom is to be applied correspondingly, in order to obtain accurate calculation results.

Under these preconditions the the bench wise masscalculation results for the West Field North *[ATT 33]* and for the West Field South *[ATT 34]* correspond satisfyingly accurate to the calculations without benches.

3.1.1.1.8 Geotechnical Investigations

The geotechnical investigations are especially important for both parts of the West Field.

The safety pillars for the Kardia power station in the West Field South and for the Ptolemais and Liptol power stations include considerable lignite reserves, which can only be exploited after the demolition of these power stations. The reserves in the safety pillar of the Ptolemais and Liptol power station are to be transported to the to the Kardia power station, and the reserves in the Kardia safety pillar will be consumed by the Agios Dimitrios power station.

The costs for the transportation of these lignite quantities can be reduced by a reduction of the two safety pillars, which calls for a careful geotechnical investigation [*SCT 1.2.3.4.5 & 1.2.3.4.6*].

The western perimeter slope of both parts of the West Field is located in a geotechnically critical position at the perimeter of the lignite basin. In this area strata dipping to the East are a risk faktor for the slope stability. At the same time the perimeter of the lignite basin is characterised by a series of geological faults, dipping down to the East. This is another essential risk faktor for the slope stability *[SCT 1.2.1 & SCT 1.2.3.]*.

In the West Field South the alignments for the road and the railway line Ptolemais / Kozani are located on top of this slope. in a small area the alignment crosses the mine area of the West Field South. A similar situation applies to the West Field South, where the the road will be relocated into a position in the West of the western perimeter slope.

The situation described above calls for a careful review of the present geotechnical assumptions.

The present status of the geological investigations and of the hydrological investigations is at present not yet sufficient for this geotechnical analysis..

3.1.1.1.9 Hydrogeological Studies

An assessment of the dewatering requirements for the Sector 6 mine, which is exploited together with the Westfield South, has been presented in *[SCT 1.2.2]*. increasing dewatering requirements and a lack of submersible pumps is stated.

For the West Field North no groundwater Information is available at present.

Surface dewatering problems in the LCPA mines have been dealt with in *[SCT 1.2.2]* of this report. The design of durface dewatering facilities calls for the availability of rainfall and runoff patterns. This information is not available at present.

The necessary investigations to groundwater and surface water problems have been proposed. The results cannot be expected within the time schedule of the TMMP

3.1.1.2 Dumping Site West Field North & South

For the Dumping sites of both parts of the West Field the following subjects are to be dealt with according to the scope of work:

- Geotechnical investigations,
- balance of dumping volumes

- Dump positions
- dump side drainage

3.1.1.2.1 Geotechnical Investigations

The general scope of work for the investigation of the stability of dump slopes is presented in *[SCT 1.2.3]* of this report. It applies for both parts of the West Field as for the other mines.

There are two problems to be dealt with:

The spreader slopes on the benches of the mines must be kept stable by not exceeding the so called limit height. This figure depends on the properties of the dump material, which depend strongly on the status of dewatering. The easiest way to determine it, is a dumping test with representative dump material.

If the dump material is wet (Status of dewatering), we are not only to expect a strongly decreasing limit height. Additionally the stability of the total system of spreader slopes will be reduced by pore water pressure effects. This applies especially, when the dumping front is in a position with minimum bench width (E. g. in the critical mine position). If wet, unstable material is to be dumped, a standard cross section is to be designed (The stable and the unstable material are to be excavated and dumped selectively, in order to assign both kinds of material to the appropriate locations in this cross section.

At present we assume a dewatered status for the future mine operation. Under this precondition the assumed limit height of 20 m is realistic, and pore water pressure effects must not be expected on the dumping site.

3.1.1.2.2 Balance of Dumping Volumes

The balance of dumping volumes for the two parts of the West Field is part of the masscalculat[illegible]s carried out during the conceptional planning phase *[SCT 2.3.2.1]*.

3.1.1.2.3 Dump Positions, Bench Levels, Evolution of the Conveyor System

The dump positions, the bench levels and the evolution of the system of dump belt conveyors in the West Field South are presented in mine positions, mentioned in the contract *[SCT 7.2.1.3 & 7.2.1.5]*

3.1.1.2.4 Dump Site Drainage

The drainage of the dump surfaces is important for the maintenance of the stability of the dump slopes. The design of the dump drainage system calls for the availability of rainfall and runoff patterns *[SCT 1.2.2]* and the catchment areas on the dump must be known. Due to the second precondition the desing of the inpit drainage system is regarded as a mid term planning activity. Rainfall and runoff patterns have not yet been established.

3.1.1.3 Electro-Mechanical Equipment

Three subjects referring to the electro-mechanical are included into the scope of work:

- Additional equipment requirements
- Schedule of equipment operation
- electric power supply

3.1.1.3.1 Additional Eqipment Requirements

This matter has been dealt with in context with the conceptual planning for the two Parts of the West Field as for all other PPC mines *[SCT 2.1.1.1. & 2.1.1.4]* . The options are to employ eqquipment from the amyntaion mine first for thedevelopment ofthe West Field North and then for the built up of the capacity of the Sector 6. As an alternative the employment of South Field equipment in the sector 6 has bee proposed. PPC s decision for one of our our proposals is still pending.

3.1.1.3.2 Schedule of Equipment Operation

The schedule of equipment operation for the two parts of the West Field as for all other PPC mines is presented in *[ATT 12 - 05 / 09]*

3.1.1.3.3 ...ctric Power Supply

According to an agreement between DAO and the Masterplan Team the basic Information for the ... the power supply for the West Field North has been supplied to DAO s electrical engineers by the Masterplan Team. They will execute this activity on the basis of the mine planning information prepared by the Masterplan Team.

We received a written statement after the kick off meeting referring to this matter, informing us, that the remaining time for the planning and erection of the energy supply for the West Field North is not sufficient *[SCT 7.3 - 20 - 0]* .

3.1.1.4 Earth Moving & Civil Engineering Projects

This section of the report is to desribe the subjects

- land acquisition requirements,
- resettlement of villages,
- removal of the Ptolemais and Liptol Power stations,
- removal of the Kardia power station,
- general earth removal requirements.

3.1.1.4.1 Land Acquisition Requirements

The production schedules for the two parts of the West Field have been the basis for our determination of the land acquisition requirements. on this basis The mine positions stipulated in the contract have been prepared. They indicate the land acquisition requirements in future *[SCT 7.2.1.3 - N°27 - 34 & SCT 7.2.1.5 - N° 21 - 27]*

3.1.1.4.2 Resettlement of Villages

n the two parts of the West Field there are two villages to be relocated.

In the West Field the two Komanos villages Komanos West and Komanos North are to be resettled by 2013 or 2019.

In the West Field South the Pontokomi village is to be relocated by the year 2020.

3.1.1.4.3 Demolition of the Ptolemais and Liptol Power Stations

Geotechnical considerations result in a safety pillar around the Liptol and Ptolemais power stations. The lignite reserves in this safety pillar must not be exploited prior to the demolition of the power station.

The time schedule for the demolition of the Liptol and Ptolemais power stations has been designed in *[SCT 1.1.1.7]* . This schedule *[ATT 6 - 9 & 10]* is a result of considerations referring to the remaining reserves. Changing reserves are a reason to review this schedule.

According to the present schedule The first unit of the Liptol power plant will be closed down in 2003. the second unit will follow in 2007.

The Ptolemais power plant is scheduled to decommission between 2005 (Unit1) and 2015 (Unit 4).

3.1.1.4.4 Demolition of the Kardia Power Station

The West Field South will be reaching the safety pillar of the Kardia power plant in the year 2025.

Accordingly the units 1 - 4 of the Kardia power plant are on schedule d to decommission between the years 2022 and 2025 *[ATT 6 - 9 & 10]*.

3.1.1.4.5 Other Earth Removal Works

In order to expedite the development of the West Field North it is suggested, to employ contractors for the development of the boxcut for the first excavator.

From our point of view, there is however no possibility, to substitute the capacity of a bucketwheel excavator over a longer period of time by contractors.

3.1.2 Requirements of Main Mine Equipment for the Amyntaion Mine

According to our point of view there is no necessity, to procure additional main mine equipment for the Amyntaion mine.

The main reasons resulting in this statement are:

- The mining ratio determined on our masscalculation is considerably lower than assumed in the past.
- The utilisation of the equipment is especially hampered by „bottlenecks" (Lack of a spreader, lack of theoretical capacity -dump conveyor lines, lack of drive power -dump conveyor lines).
- The third unit of the Amyntaion power station will not be erected (the remaining reserves of the Amyntaion mine are too small).

A cost comparison of the first two methods described above shows, that the application of crushers results in higher costs for the removal of the hard material. This result corresponds to the experience achieved in our own mines and abroad.

Another disadvantage of the crusher application is, that the theoretical capacity of the spreaders in the South Field is not sufficient for the operation of the BWE and the crusher at the same time.

It is suggested not to continue the present method of hardrock removal with cruschers Method B) in the South Field. It should be substituted by the Method A. The crushers can be used semistationary close to the main hard rock deposits at the eastern perimeter of the South Field for the production of road construction material. The application of the Method A requires good haulage raoads for the truck transportation and good mine roads are genenerally an advantage.

3.1.5 Options to increase the Utilisation of the Equipment in the LCPA Mines

The options to generally increase the eqipment utilisation in The mines of the LCPA have been described in *[SCT 1.3.2]*

3.1.6 Excavation Works by Contractor

Excavation works by auxiliary equipment (As far as possible with PPCs own eqipment andas far as necessary by contractor) should be taken into consideration in the following cases:

Komanos Mine, Expit Dump N° 2:
This is an overheight area, where the operation of conventional equipment coud be the better solution compared to the employment of BWE. This applies especially, if the transportation distance for the trucks can be kept short.

Boxcut West Field North:
The dedevelopment of the West Field North should be expedited by the preparation of the boxcut with conventionsl equipment.

We do, however, not suggest, to substitute the capacity of the first excavator for the West Field North during an extended period of time by conventional equipment. As we see it, there is no necessity, to do so and this procedure is regarded as not feasible.

Lignite Supply for the Dry Lignite Production:

From our point of view the lignite for the production of dry lignite (and briquettes) should not be supplied by BWE. We see the necessity to excavate this lignite quantities in various mines, whereever a good quality of the undiluted lignite is found. The most likely supplier of this lignite is the South Field. To excavate this high quality lignite as undiluted as possible requires the employment of conventional equipment. The missing transportation link to the Liptol facilities calls for truck transportation (In principle one could erect a belt conveyor. this is, however most likely not justified due to the small yearly quantity).

3.1.7 Safety of Lignite Supply (Interlinking Transport System, Reserve Fields)

In the scope of workt two options to ensure the safety of the lignite supply are mentioned. These options are the (early) development of reserve fields and the installation of an interlinking system for the transportation of lignite connecting each mine to each power station.

Apart from these two options The low level of equipment utilisation assumed up to now in our production schedules, the reserves of lignite assumed at present (too low) and the mining ratios we have calculated (too high) present an additional safety of lignite supply.

Reserve Mines:

We can exclude this option. The only future mines in the LCPA are the two parts of the West Field.

The West field South will be exploited with the Sector 6 mine area as one mine. This is the most economical variant of exploitation for this field.

An development of the West Field North earlier than scheduled at present is not feasible.

Railway System for the Transportation of Lignite:

At the Start up of the preparation of the TMMP a railway system for the transportation of lignite from each LCPA mine to each LCPA power station has been taken into consideration. Tecno-economical reasons result in the rejection of this option from our present point of view.

Belt Connections for the Transportation of Lignite:

The lignite reserves in the safety pillars of the Ptolemais/ Liptol and Kardia power stations require transportation links (belt conveyor syxems) between the West Field North and the Kardia Power station or between the West Field South and the Agios Dimitrios Power station. These facilities are increasing the safety of supply for the Kardia power station and for the Agios Dimitrios power station.

3.1.8 Requirements of additional Main Mine Equipment

As a general guideline for the design of the Technical Mine Master Plan for the LCPA and for the review of the existing conceptual planning for the LCM we avoided the procurement of additional main mine equipment. Ths target was achieved by the development of an appropriate schedule of operation of the lignite fired power stations in The LCPA and the LCM *[SCT 1.1.1.7]*. As a consequence the lignite demand starts to decrease after the year 2000 *[ATT 12 - 1 & 2]*. The total excavation requirements start to decrease as well after the year 2007 *[ATT 12 - 3 & 4]*.

Based on our present conservative assumptions referring to the mining ratio and to the utilisation of the equipment no additional eqipment is required.

3.1.9 Production Schedules

See section *[SCT 2.3.2]*

3.2 Review of the Concept of Development for the LCM

The scope of work stipulates a review of Professor Goergens Study for the LCM aiming to check and modify the schedule of equipment commissioning in the LCM.

As the basis for this activity the remaining reserves in the LCM have been calculated *[SCT 1.2.4.3]*,The concept of development has been reviewed *[SCT2.1.2]* and production schedules have been prepared *[SCT 2.3.2.2]*. Assuming that the schedule of equipment commissioning proposed in the Goergen Study *[SCT 7.3 - 7 - 0]* is no more valid, we checked the present schedule of equipment commissioning *[SCT 7.3 - 21 - 0]*.

During the preparation of the Technical Mine Master Plan the development of the Horemi mine has been executed with a small delay. The benches 4 and 5 on the excavation side of Horemi commenced operation in July and October 1995.

The last excavation bench and is scheduled for commissioning in March 1996. The first bench of the inpit dump will follow in December 1996. This schedule is realistic from our point of view.

The two missing benches of the inpit dump of Horemi, which are not mentioned in the schedule provided by the LCM must commence operation until the volume of the expit dump is is exhausted. This will apply in the year 2003.

In the Kyparissia mine the employment of a dragline in the overheight area (Sectors 2 - 4) has been taken into consideration in the past. The Masterplan Team suggests not to adopt this proposal:

4 Phase 4: Lignite Quality - Ash Transportation - Environment

In this section of the report the following general problems, are to be dealt with according to the scope of work:

- Stockpile Management
- Ash transportation
- Interlinking wsystem for lignite transportation
- Earth removal and civil engineering projects
- Environmental study for the Kozani - Ptolemais - Amyntaion basin
- Personnell - personnell training

4.1 Stockpile Management

PPC s lignite mines are to supply the consumers with lignite in satisfactory quantity and quality. Both objectives are contradictory to each other.

The safety of supply calls for the maximum possible stockpile volume as a buffer between the mine and the power station.On the other hand the lignite quality can only then be kept constant within narrow limits, if a part of the stockpile volume volume is assigned to blending purposes.

Hence the optimum stockpile management is to compromise between both purposes.

The present strategy to keep the large stockpiles completely filled up whenever possible is not the optimum approach, as we see it.

A detailed analysis of the methods of stockpile management has been issued in the past *[SCT 7.3 - 23 - 0]*. In the following sections of this report a summary of this analysis will be presented.

4.1.1 The Regulation of the Lignite Quality

In context with the regulation of the lignite quality
the specifications of the power stations and
the methods to keep the quality of the production within the specified limits
are to be described

4.1.1.1 Lignite Quality Requirements

The quality requirements, as specified by the power stations have been described in the phase 1 of the preparation of the TMMP *[SCT 1.1.3]* . Because in the case of PPC s multi layer deposits the lignite quality and the quantity are strongly related to each other, it is essential, to keep the actual lignite quality close to the calculated quality parameters. This holds true , because:

- The calculated calorific value of the lignite is only slightly above the power stations specification, to achieve the maximum possible reserve of exploitable calorific energy. if the actual calorific value is not observed and steered appropriately, there will be problems in the power stations due to insufficient lignite quality or quick variations of the lignite quality.
- Additionally the actual lignite quantity will be different from the calculated figure in this case.

In this context the procedures of steering the exploitation of the deposits according to the masscalculation results are to be described.

4.1.1.2 Masscalculation Results as a Base of Quality Steering

The lignite quality and quantity as determined in our masscalculations depend on a sophisticated set of criteria (Minimum thickness for the selective excavation of waste and intercalations, mining loss and dilutions, cut off limit for the ash content, quality parametres for thestrata without analysis). The result is an accumulated thickness of lignite and the corresponding average quality paremetres, which are then used as the input for the assignment of these figures to the corner points of the masscalculation grid by an interpolation algorithm.

Unfortunately this information is no useful guideline for the selective excavation of lignite and waste in the mine.

As a result of the masscalculation procedures described above, there is no geometrical representation of the lignite and waste volumes available after their application. what we know is the accumulated thickness of lignite and waste at any corner point of the masscalculation grid. additionally we know the position of these accumulated thicknesses between the mine bottom and the top of the lignite bearing series.

In this situation even a very experienced bucketwheel operator cannot hit the target, set by teh masscalculation.

He could know the accumulated thickness of lignite and waste, he is expected to separate from each other, but he does not know where in the excavation front the waste and lignite blocks are.

He could know the criteria of evaulation but he has no information about the actual quality of the layers exposed in the excavation face. Even if this information would be made available, he is not in the position to repeat the process of evaluation „manually" in the moment of excavation in his operators cabin.

We doubt, that face mapping can improve this situation considerably. In principle The process of evaluation for the masscalculations is to be repeated based on the results of face mapping. The expoitable lignite and waste block are then to be marked in the excavation face of the front block. we cannot imagine, that any PPC mine has got the required staff for activities as such.

Instead of that the bucketwheel operator can only rely on his experience and on his capability, to assess the effects of his actions.

This fact ad the present use of the stockpiles, which emphasises their function as a buffer between the mine and the consumers is the reason for the considerable variations of the lignite quality observed in the past.

In cases as such „mother nature" applies feed back mechanisms, and according to our point of view we should aslo apply them for the steering of the lignite quality

4.1.1.3 Quality Recording

The first element of the feed back mechanism for this purpose is theknowledge of actual lignite quantity and quality on the lignite conveyor of each mine.

For this purpose facilities for the measurement of the lignite weight (Belt scales) and facilities for lignite sampling and analysis are to be installed in the lignite conveyors of each mine. necessary. Measurements are to take place before the lignite is dumped into the stockpile sect[illegible], assigned for the blending of lignite.

The lignite quantity and quality is then recorded regularly. The blending procedure, to be described la[illegible] [illegible]mands to first fill up a certain section of the stockpile completely and then to empty it again completely.

The kind of equipment for sampling and quality analysis and the frequency of sampling is a subject for the follow up activities after the completion of the TMMP. At the time being it must be sufficient, to describe the procedure is principle.

The ash content, the lime content in the ash, the water content and the calorific value of the lignite is to be analysed.

These quality data are then the input for the calculation of corresponding moving average figures. A period of time, which must be adjusted to the filling time for the stockpile section for blending purposes (about 10-20 % of the total filling time), is regularly shifted forward (by a shift of a day) and the average quality figures for each of this moving periods of time are calculated.

The objective of this procedure is, to equalise the inevitably varying lignie quality-#.

4.1.1.4 Quality Steering

The steering procedure itself is rather simple. The accuracy of the process of selective mining is influenced, to bring the moving average of the quality figures back closer to the selected standard figure, as soon as a deviation is stated.

If e.g. the moving average of the calorific value is above this standard value (Masscalculation result), we must assume, that the lignite quantity, exploited during the respective time period for the calculation of the moving average, is smaller then possible. The bucketwheel excavators can then be allowed, to include more low grade lignite into the production.

As a consequence the moving average of the calorific value will start, to decrease again. As soon as the moving average figure is too far below the selected standard figure, the operators of the bucketwheel excavators are again to exclude more of the low grade lignite from the lignite production.

This a feed back circle in principle.

As a result of this feed back procedure the variation of the quality parameters will already be reduced by far. Only slight variations in an area above and below the set standard figure are to be expected.

This remaining variation is the reason why a certain fraction of the stockpile volume must be assigned to blending purposes. If the volume for blending does not include a sufficient number of quality changes, no good blending effect can be expected.

4.1.1.5 Blending Procedures

The basic principle of blending lignite of varying quality in a stockpile is, to stack and reclaim the lignite in layers crossing each other. By the application of this principle the layers of varying quality are recalaimed almost simultaneously. The different lignite qualities are blended with each other.

The quality of this blending process depends on the stockpile volume for blending and on the pattern of quality variations. The variation of the lignite quality is already reduced by the quality steering measures described above. In order not to reduce the buffer of the stockpile too much, we propose, to assigne 1/3 of the total stockpile volume to blending purpose. The normal situation will then be:

- Reclaimer operation in one third of the stockpile volume,
- stacker operation in another third of the volume,
- the last third of the volume is a safety buffer in the case of lacking production in the mine.

The blending effects are decribed below.

The stacking and reclaiming of the lignite in layers crossing each other can be achieved by stacking the lignite in layers, crossing the longitudinal axis of the stockpile (Slewing movements of the discharge boom of the stacker) and reclaiming it in layers, in parallel to the longitudinal axis or

by stacking the lignite in layers, in parallel to the longitudinal axis of the stockpile and reclaiming it in layers crossing, the longitudinal axis (small cell method)

The applicability of both methods depends on the construction of the stackers and reclaimers of the stacker- reclaimers.

One of the methods described above or another of the known blending methods is to be applied according to the constructional properties of PPC s stockpile equipment.

If the lignite passes a mine stockpile and a power station stockpile prior to consumption in the powerstation the blending procedures, described above, should be applied twice.

We are confident, that this procedures will result in an almost constant lignite quality close to the masscalculation result.

4.1.2 The Buffer Functions of a Stockpile

The second objective of the stockpile management is the safety of supply.The stockpiles serve in this context as a buffer between the mines and the lignite consumers.

In this context the variations of the lignite demand are essential *[ATT 23]*. There is a shorter peak period during the summer (Air conditioning) and a longer peak period during the winter months

The order of magnitude of these variations cannot be overcome with a big stockpile alone. Especially during the winter peak the level of lignite release must be raised by planning measures *[SCT 1.3.2.6]* . even PPC s big lignite stockpiles *[ATT18 15]* will not be sufficient for these variations of the lignite demand in any case.

4.2 Ash Transportation

The methods of ash deposition are related to the environmental aspects of the lignite based electricity generation. correspondingly we have described this matter in *[SCT 4.6.5]*

4.3 The System of Interlinking Lignite Handling Systems

See *[SCT 3.1.7]*

4.4 Earth Removal and Civil Engineering Projects

See *[SCT 3.1.6 & 3.2]*

4.5 Environmental Environmental Study for the LCPA

The environmental impact of lignite mining inclludes the following aspects:

- Reclamation of the mined out areas,
- The influence on groundwater and
- surface water,
- the deposition of the ash in context with the future quality of the groundwater
- dust protection measures,

- noise protection measures.

4.5.1 Recultivation of the Mainfield Area

In the past PPC s mines in the LCPA (and in the LCM) have left considerable areas unreclaimed. In order to improve the acceptance of the mine operation by the public, the reclamation of these areas is an essential future task.

From our point of view it is important, to prepare the reclamation areas as far as possible with the main mine equipment already. This calls for selective mining and dumping of the soil types, which are most suitable for the subsequent recultivation of the dump surfaces.

The preparation of the Ptolemais reclamation area has been described in *[SCT 2.4]* . The following sections describe the subsequent recultivation activities.

4.5.1.1 Theoretical Considerations

Every human activity involves changes in the environment. On the one hand, this means a loss of existing qualities, and on the other hand, it also signifies the gain of new qualities. The loss of a certain quality always entails the risk that certain properties considered especially valuable will irretrievably be lost. The risk of this possible loss has to be balanced against the possible gain from the interference and the new properties to be expected from this change.

If we look at lignite opencast mining, the possible gain is unquestioned. In Central Europe, lignite is the most important domestic energy raw material and makes a decisive contribution to ensure low-priced and stable energy supplies. It constitutes an important guarantor of the economic efficiency and the living standard of sophisticated societies. At the same time, the great number of successful recultivation examples prove that -at least under the macroclimatic conditions prevailing in Central Europe- it is feasible to create new post-mine landscapes, the essential properties of which are by no means inferior to the surrounding landscapes.

Recultivation of land affected by surface mining represents an intentional and creative act of man. Even if we take account of the many restrictions due to technical restraints (e.g. material flow routing, geological and hydrological conditions or natural scenery), an immense creative scope is left. Within this scope it is necessary to define the targets to be achieved by these creative activities according to criteria that can be rationally reconstructed. These targets can then serve to determine the appropriate measures. In this context, recultivation represents a learning process that is subjected to a constant feedback process with the measures carried out.

In order to define these targets we have to consider in what way human interference affects nature and landscape and what criteria can be applied to assess this interference. Furthermore, we have to define the concepts of value these measures are to fulfill.

4.5.1.1.1 Ecological Fundamentals

The lasting usefulness of a cultivated landscape is based on a multitude of networked biological processes. During recultivation it is therefore important to continuously assist and control the recolonization of typical living organisms as functional units of these biological processes. For this purpose, it is necessary to know the proceeding developments and the major ecological fundamentals and to define a number of terms that are frequently used in the general discussion.

The biological processes during the development of life communities often proceed according to certain patterns and lead to more or less clearly defined final conditions that are similar at different places of a region. These final conditions of the living community's development are referred to as *climax*. This concept was coined at the beginning of this century. The monoclimax hypothesis assumed that there is only one climax community in a specific macroclimate. The climax was imagined to be an unchangeable system that under the conditions prevailing in each case will reach the highest level of constancy. This model suggests that communities of living organisms are "hyper-organisms", which are marked by an inherent instinct of long--erm self-preservation. Soon, however, it became clear that this approach did not come up to the conditions observed, and in the course of time the concept has been more and more extended.

This becomes even clearer for animal life communities. Among the living organisms of these communities all conceivable forms of positive and negative correlations can be realized. In this context, the competition among the living organisms is the strongest factor shaping the communities. Such climax communities are no unchangeable systems. Even under constant environmental conditions they are subjected to a continuous change. Even virgin forests are not really permanent systems and capable of self-preservation. Beech virgin forests in the Balkans showed that the trees when having reached their physiological age gradually die off. They are followed by a community of photophilous herbs and shrubs, which are then replaced by a forest of fast-growing photophilous species. It is only in its shade that new beeches grow and again replace the other species due to light competition, thus constituting a pure beech forest.

This cycle recurs as long as neither climatic changes nor new or changed species occur. In this process, mosaic stands are formed in the forests described, which constantly show all elements of this cycle. If we still speak of a self-preserving climax community in this context, we will hardly describe this observation correctly. For this reason, these conditions are referred to as a mosaic cycle. Thus, climax has changed from the idea of a definite life community to a description of the amount of all possible system conditions, which occur in a specific environmental situation. This results in the important discovery that the evolutive pressure is not exerted on the strengthening of the individual life community's self-preserving mechanism, but on the support of its regeneration capacity after disastrous changes.

The considerations so far have been based on constant environmental conditions and have shown that even under these conditions the constant change is a characteristic feature of biological systems. In reality, however, the external underlying conditions are also subjected to constant changes. In some cases, it is even the life communities themselves that trigger these changes in the environmental conditions. Against this background, the appearance of the observable life communities is changing in the course of time, with many changes being practically dependent on mere chance.

In many cases, however, changes in the life communities are predictable. So, we know quite exactly that retrogression to a forest after clearing takes place via different stages with herbs, shrubs and tree species, similar to that according to the mosaic cycle model. Such a controlled sequence of different life communities towards a climax is referred to as *succession*. According to the outdated concept of climax as the "hyper-organism", succession was understood to be the strictly determinate individual growth and maturation of this climax community. This concept is surely wrong, and succession, too, is considered in a more differentiated way today. Succession is understood to include all changes in life communities, i.e. both the development towards climax and the changes within the great number of possible climax system conditions under constant environmental conditions and, in addition, the developments of climax under changing underlying conditions.

It was above all the chance factor that did not meet the original deterministic model. But it has turned out that a multitude of developments are not reversible and that accidental influences of the smallest extent and considerably intensified by the further development can lead to completely different results. Therefore, it is by no means feasible to exactly predict succession and climax. But the type can be stated to which the climax will correspond. Thus, it can be assumed that on all Central European soils, which do not react in a directly hostile manner to vegetation, a forest will develop as climax. On the basis of the site-specific demands made by the domestic tree species it is in most cases even possible to assess what tree species will form these forests. Furthermore, the course of development can be assessed as well. Hence it goes without saying that first wind-dispersed herbs will dominate the landscape, which are followed by wind-dispersed tree seeds, such as birch and willow.

In terms of recultivation it can be stated that in the course of succession new life communities will form. The respective climax will be dominated by the most longeval life communities. In view of the ecological parameters, such as regeneration capacity, constancy of species, elasticity, the new systems that are developing will behave in the same way as those systems that have emerged without human influence. The rapid pace at which these developments can take place is already today reflected by a great number of examples on abandoned arable land, the development of new land in polders along the North Sea coast or on industrial fallow land. A particularly impressive example of such developments is the fields with high heavy metal loads on former ore mining dumps in North Rhine-Westphalia. Here, the specific site conditions have given rise to the development of particular, well-defined plant communities, and -due to evolution- some specific species have emerged that only occur in this particular area.

A distinction between succession areas and normally reclaimed areas is misleading. These areas only differ in the duration of human interference, for the former are only subjected to deliberate interference during the first phase, i.e. dumping of substrata. The rest is left to chance. Even the attempt to quantify the extent of interference with the succession areas must fail. It is quite conceivable that in some place the soil-specific properties exert a considerably greater influence on succession than, e.g., a continuous attending activity in a forestry cultivation on another dumping substratum.

The description of potentially natural vegetation (pnV) means the attempt to reconstruct how vegetation would be without human influence. In this context, the respective site is compared with sites that have similar properties and exist, with the minimum influence possible being exerted. The difficulty of this approach has been reflected in the "retreat" of oak from the phytosociological systems since the start of this century, or in the problem of defining pnV for locations, the soil characteristics of which were seriously changed by excess use and deforestation.

Such a site-specific approach is an important instrument for a rational selection of species appropriate for the particular location, e.g. for creating a forestry cultivation. At the same time, the attempt to define pnV on new recultivation sites includes the risk of overrating the quality of such plausible assessments. In a particularly clear way this is shown by the attempt to assess the value and the ecological condition of recultivation by its similarity to the vegetation that due to its site-specific parameters would be expected to exist in "unworked areas". This conclusion would be permissible only provided that the pnV expected exactly corresponded with the climax towards which the system investigated is developing. This assumption, however, is surely not justified with regard to the soil formation processes and unpredictable, accidental events.

4.5.1.1.2 Essential Ecological Requirements

During the colonization of newly created biotopes, as in the case of recultivation, the following three factors play an important role in view of the climax community development, viz.:

- immigration of species
- competition
- site-specific properties.

The example of the special grass, i.e. calamagrostis epigeios, frequently occurring during the recultivation of the German mining areas can explain the effect of these factors. This grass is a plant with wind-dispersed seed. It virtually occurs in all forests and on fallow land so that its seed is everywhere capable of very quickly immigrating into the reclaimed areas. When it has taken root, it is very competitive thanks to its storage roots that survive many years in the soil and sprout early in spring. Furthermore, the grass only requires very small nitrogen quantities in the soil -a lack that is a frequent feature of reclaimed soils. Due to the above properties the calamagrostis epigeios is simply made for playing an important role in the colonization of reclaimed areas.

According to sowing tests, other grass species, such as the tall oat grass or the orchard grass, would also cope well with the conditions prevailing on reclaimed land. They, however, are not dispersed by wind so that they hardly have the opportunity of colonizing on reclaimed areas. In the places where they get by chance or where they are sown, they often succeed in taking the place of the calamagrostis epigeios. With natural succession advancing, this grass is overgrown with birches and willows and slowly displaced due to competition for light. In those places, however, where these trees have a reduced thriftiness, e.g. on compacted sites, the calamagrostis epigeios can survive for many decades.

This example already shows how succession can be influenced in the course of recultivation. At two points, those in charge of recultivation interfere:

- During dumping of reclamation substrata, important site-specific factors are defined.

- Development measures, such as the laying-out of forestry cultivations or interim farming, influence the course of succession and promote desired elements.

Since the earliest investigations the dumped substratum has proved to be the decisive site-specific factor exerting an influence on succession -this is also confirmed by the general theoretical investigations into the system stability of life communities. One property is equally typical of all dumped soils, viz. the low C and N contents. Above all, the more exacting species might be seriously hampered in terms of their development, even if they have the chance of immigrating. Besides this general property of virgin soils, it is above all two factors that are decisive in view of recultivation, viz. water economy and density.

Immediately after dumping, the physical soil conditions are optimum. To secure this state it is necessary to plant forestry trees and shrubs and sow grass as quickly as possible. In this connection, travelling on areas in the course of mechanical planting is to be avoided. Experience has shown that direct planting of forestry trees and shrubs by hand has yielded the best results.

In almost all investigations, the species' dispersal capacity has been found to be a particularly essential factor influencing succession during recultivation. In the first few years, the shares of wind-dispersed plant species were in some cases higher than 90 %. Even in old recultivated forests the wind-dispersed species clearly exceeded those found at comparative sites of land not affected by mining. The great significance of the dispersal capacity becomes also clear if we consider that according to extended-time investigations half of all phanerogams have already taken root during the first two years.

As expected, the immediately adjacent land exerts a considerable influence on colonization. The effect of barriers preventing the immigration of less vagile species despite potential site-specific suitability was demonstrated in the case of grasshoppers and carabids. Another proof is furnished by the occurrence of foreign floral elements, which were sown near recultivated investigation areas and have then become important elements of the succession course. Another interesting fact is that succession was considerably shortened on areas that had been subjected to digging and harvesting during a succession test -a phenomenon that was obviously due to the influence exerted by the now nearby areas of older stages.

As a consequence, the object of landscaping in the course of recultivation must be a logical, physical compound of the landscape elements. It does not suffice to offer isolated biotope islands arranged as small units allowing animals to migrate from one biotope to the other since populations developing on recultivated land are dependent on the continuous influx of individuals from the unworked land. Due to the barrier effect exerted by roads and paths it is important to minimize the network of the completed system. In the field of forestry recultivation it is possible to consider special lanes instead of a densely developed road and path system already during the planting of cultivation. These lanes can act as fire protection and permit wood moving in the future. In agriculture, a feasible solution is the layout of meadowed paths.

4.5.1.1.3 Free Areas (Meadows)

Free areas constitute an important element of our cultivated landscapes. As a result of interference by man, they emerged directly from forests in former times. In those areas where they have not been fertilized but extensively cultivated, meadows and pastures together with heathland are the nearest-natural biotopes next to the forest. Since in the past they often represented the prevailing landscape elements in the course of pasture farming, there has been a multitude of species and life communities depending on these cultivated biotopes. Accordingly, free areas form an important element of landscape-adapted recultivation. In the course of its planning, account has to be taken of the fact that in Central Europe no successional series exists that results in the development of meadows or pastures. The latter have therefore selectively to be sown and tended from the very beginning. For this purpose, herb-rich meadow mixtures with approx. 4 % wt herb and 1 % wt leguminosae portions should be chosen.

For tending, mowing and mulching are suitable to meadows, and pasturing to pastures. At present, the only tending that is low-priced or even cost covering may be pasturing by sheep. These are ideally herded, but can also remain behind fixed nets for some days. During the night they should be penned up. Here, it is best to always choose the same locations. Thus, some small areas are enriched with nutrients allowing nitrogen-preferring plants to grow. Since the soils are prone to compact, it is not appropriate to make large numbers of cattle or horses graze there at least during the first few years and, by no means, on areas designed as permanent pastures. An economically interesting utilization may also be extensive keeping of fallow deer on smaller areas.

Mowing is the most expensive type of tending, and in view of the declining hay prices it cannot economically be implemented without the possibility of direct utilization. If the hay had to be composted, mowing would be impossible anyhow. On meadows in unworked areas, too high nutrient loads have generally to be decomposed in order to maintain the richness in species there. Therefore, it is always recommended to cut the meadows and cart off the hay. The cheaper mulching variant where the hay remains chopped on the meadow involves extremely species-poor and matted communities of nitrogen-preferring species. The reclaimed areas, by contrast, are very poor in nutrients anyhow. In this case, mulching, too, seems to be a suitable tending method -at least during the first few years and decades, and this all the more since the dying plant material is an important nutrient for the soil fauna.

4.5.1.1.4 Succession Areas

In the course of every large surface mining operation, there is the opportunity of making succession proceed without any further tending measures. In principle, this is advantageous in those areas where no direct utilization interests are given, no plant-damaging substratum occurs and no danger exists that, e.g., erosion constantly hampers succession. Where these preconditions are met, even large areas can be absolutely left on their own. These areas will then gradually develop into a forest. This approach is expected to be all the more successful and proceed all the more quickly, the closer the recultivated area is to the virgin land. Such areas are of great interest not only to nature conservation, but also to science. Here, it is possible to observe how succession without being influenced by man proceeds, a possibility facilitating a better understanding of the processes taking place in the course of normal recultivation.

It is above all in wetlands that at a regularly rapid pace succession without being influenced by man leads to life communities being both attractive in terms of landscaping and interesting in terms of nature conservation. This is due to the fact that even under natural conditions small dead waters are very short-lived biotopes and have to be constantly recolonized. Therefore, the appropriate species have good dispersal mechanisms. Furthermore, waterfowl are excellent dispersal media. For this reason, ponds and areas with alternating wetness should be left on their own. Only if there are the appropriate structures in the zone in advance of the mine, plants and mud can be taken from this area in order to permit initial planting and inoculation. On no account are plants to be used that are available on the market.

During the configuration of lake shores, it has to be considered that typically zoned shores with a floating plant belt, an extensive reed bank and adjacent swamp meadows can only develop if the shore has an 1:40 or even flatter inclination. In this context, it goes without saying that this inclination should be maintained beyond the average water line to permit upcountry development of the important areas with alternating wetness as well as wetlands. Such structures are typical of dead waters in flat countries and also correspond to the natural scenery of the Ptolemais region. Under these conditions, and if the substratum does not get compacted, a valuable biotope will very rapidly develop by itself.

Neither for brooks continuously carrying water is it necessary to specially plant the water zone. Attention, however, is to be paid to the fact that the small animals can freely pass over the entire brook's bed, thus allowing them to colonize upstream. Therefore, passages should have a clearance of about 1 m and the bed should be covered with at least 50 cm of the normal soil substratum.

4.5.1.1.5 Agricultural Areas

The following subjects are to be described under this headline:

- Procedure, Fundamentals
- Agricultural Underlying Conditions
- Sequence of Agricultural Recultivation Work

4.5.1.1.5.1 Procedure, Fundamentals

The recultivation types to be aimed at are subject to the restrictions imposed by the direction of opencast mining and the natural underlying conditions. While the direction of opencast mining -and in particular the construction of the dump surface- can be modified to a certain extent, the natural preconditions are largely predetermined by the availability of suitable material. The economic underlying conditions, however, are to be considered fluid. On a supra-regional level, privatisation of agriculture changes the intensity of soil utilization, thus having an indirect impact on the demand for agriculturally recultivated areas. The impossibility of multiplying the resource 'soil' calls for the utilization of material that is best suitable for recultivation. In this context, the maximization of useful agricultural areas must by no means be given priority.

4.5.1.1.5.2 Agricultural Underlying Conditions

The privatization of agriculture currently underway and the resulting consolidation of agricultural operations make it more difficult to assess the demand for agriculturally recultivated areas. But due to the declining agricultural protectionism and the opening European agricultural market, only higher-quality agricultural areas are expected to continue to be used accordingly in the future. Besides a purely yield-oriented agriculture, lower-quality sites will possibly serve landscaping purposes as well.

4.5.1.1.5.3 Sequence of Agricultural Recultivation Work

It is to be checked to what extent it will be necessary to continue the special operation of topsoil spreading, or whether the topsoil is to be transported via belt conveyors and spread by spreaders (with reduced performance). That is why the following considerations will not take account of waste and topsoil transport but regard soil spreading as completed. It is in particular for spreader operation that we recommend monitoring the material flows by means of a rotatory laser that can be excellently employed for subsequent grading work as well.

Chronologically, a distinction can be made between three phases:

1. Completion of the areas by
   - preparation of the final ground surface
   - construction and completion of development roads
   - construction and lining of drainage ditches
2. Pioneer or interim cultivation by means of
   - alfalfa cultivation
   - inspection of the area quality
   - amelioration and rehabilitation, if required.
3. Preparation of the areas' handover
   - Stock of areas
   - Selection of buyers
   - Transfer

The final ground surface is to be prepared in a way sparing the soil and avoiding compactions. To this end, as lightweight as possible equipment should be employed during favourable weather conditions. To the extent available, operational roads should be incorporated into the development plans, so that the overall network of roads and paths only has to be supplemented. The same applies to the ditch system.

The required civil engineering work can be performed by contractors using their own equipment.

For pioneer or interim cultivation exclusive use is to be made of special agricultural equipment. Where it is not planned to provide an agricultural operation with the corresponding equipment, long-term service contracts should be concluded with neighbouring agricultural operations. This may even involve the initial steps towards a subsequent sale or lease of those areas. The alfalfa cultivated not only deeply activates the soil biologically but also serves as a 'bio-indicator' indicating damaged points which have to be eliminated, if required. Such damaged point elimination should not be dispensed with especially in those cases where it impedes cultivation, which as a rule has an impact far beyond the weak point itself.

Preparation of the areas' transfer presupposes the selection of buyers. In the period required for selection measures the areas have to be kept in stock. During this period, salable fruits yielding crop proceeds can be cultivated. If the mine operation has its own agricultural equipment, it can post these proceeds to its own accounts; otherwise, the remuneration paid to the contractors is to be deducted from such proceeds.

4.5.1.1.6 Surface Drainage Measures

The surface drainage of rehabilitated post-mine land not only has the technical function of water discharge but is to fulfill further tasks within the scope of the ecological restoration of once sterile operational areas.

In general, water bodies are an essential part of the eco-balance and provide biotopes for multifarious species of fauna and flora; they shape the natural scenery. The more near-natural they are, the better can they fulfill these functions. Water bodies that have been left in a near-natural state or designed in a near-natural way constitute manifold biotopes for fauna and flora communities typical of the specific natural environment. They are the landscape's ecological backbone and have many positive effects on the surrounding area. In the past few years, the renewed reflections on these water body functions have led to a change in the demands on them and thus in the manner and extent of their design and maintenance.

Today's design and maintenance measures are not only aimed at ensuring the necessary water discharging capacity but also give equal priority to the conservation and/or restoration of biotopes for fauna and flora and their life communities.

Flowing waters are complex systems of various biotopes, viz. the aquatic field (water body and bed), the amphibian field (zones with varying degrees of humidity), and the terrestrial field (surroundings affected by the water body). These biotopes are characterized by diverse life communities (biotic communities) which are to be preserved and furthered.
Flowing waters should be supplemented by dead waters, since these produce independent life communities.

Water body, water bed, bank and surrounding areas should be designed with great diversity and left to their own development to the extent permitted by the hydraulic requirements. Water bodies are by nature subject to a constant change of erosion and sedimentation.

Under natural conditions, however, the total effect of these phenomena is compensated for by the displacement of water bed and stream line (physical equilibrium).

Hydraulic engineering measures in recultivated areas are to help find this equilibrium by the limited design with natural building materials (natural stones, wooden plugs and brushwood) or with living building materials (trees, shrubs, reed, grasses).

4.5.1.1.7 The Design of Water Bodies

Both stagnant and flowing waters should be designed as near-natural as possible to ensure ecological diversity and a physical equilibrium.

- If possible, the water body's longitudinal course and its slopes are to be modelled after the natural condition of the particular type of water body; if possible, this is to be done on the basis of old maps.
- The water body should not be fixed for permanent life by using dead construction materials.
- Bank trees and shrubs, reeds and perennial plants are to be established, and the formation of sand and gravel banks falling dry in the summertime is to be promoted.
- Small pipe diameters are to be avoided, as most animals are unable to negotiate them.
- Dead waters corresponding to the particular type of water body are to be created.
- There must be a constant, equilevel connection between dead waters and flowing waters. At least in places a dead water must be 1 m deep, if fish or amphibians are to overwinter in it.
- Precipices are to be avoided, bed slides are more favourable. Where it is not possible to transform precipices into bed slides, fish channels are to be built and tended to enable the fish to pass.
- The diversity of small biotopes in the water and on the banks is to be promoted.
- The side slopes are to be stabilized as far as possible using living building materials, above all common alder. White willow and ash, too, can help stabilize the banks. What is important for the trees' development is a sufficiently wide bank strip.
- As far as stones are needed for slope stabilization, only those types of rock typical of the particular region should be used.
- The installation of geotextiles serving as filters is to be limited as far as possible. It is to be seen to it that the filters used have the largest possible pores and are covered by an at least 15 cm thick natural substratum. This serves to maintain the function of the porous system below the water body's bed.
- The development of erosional cavities, alluviations and bank faults is to be allowed so as to obtain a near-natural structure and ensure permanent breeding sites for kingfisher and bank swallow.

- Creation of partial areas subjected to different flow intensities by installation of ground sills, groynes and disturbing stones and other measures having an influence on flow behaviour and flow pattern by means of natural materials.
- Zones of reed and high perennial plants are to be promoted.

Bed steps should be designed in a near-natural way, e.g. as ramps of large stones or bed slides. The step height should not exceed 1 m, the ramp gradient should not be steeper than 1 : 10. Precipices should only be installed if fish are able to negotiate them, i.e. with heights not exceeding 30 cm. It is advantageous to design them as resting sites for fish.

Ground sills are particularly favourable in terms of ecology, as they do not obstruct fish migration paths. However, they are hydraulically effective at low water levels only. The sills consist of rock dams; their spacing depends on the gradient, the creek width and the occurring bed material.

Cascades and other concrete structures are no elements of near-natural water body designs. They obstruct fish migration, are difficult to green and constitute optically foreign bodies within a landscape. Wherever possible, they should be replaced by near-natural structures of dead or living materials.

The creeks and ditches themselves are designed with a meandering course and slope inclinations ranging between 1 :4 (inner bank) and 1 : 2 (outer bank in the bend area); the minimum bed width should be 50 cm. Tree lines (e.g. common alder, white willow, ash) are planted in sections along the bank. For initial slope stabilization, low-growing grasses can be sown as well.

4.5.1.2 Recultivation/Factors determining Recultivation

Recultivation can be defined as follows: „Recultivation means all initiatives and measures that serve to restore the landscape and economic structure of such partial areas of the cultivated landscape, the natural efficiency of which was considerably reduced or destroyed by human interference, in particular by the extraction of raw materials".

Recultivation itself depends on various factors. Besides the deposit, the mining technology, waste dumping, uses of the land affected by mining as well as the associated obligations to return it play a particularly important part. In particular the questions of whether any cultivable material occurs at all in the area in advance of the mine and to what extent it is to be mined selectively and used again for recultivation, are some of the main factors deciding whether agricultural or forestry areas will be established. Hydrological and slope design aspects, too, play a major role in recultivation. In addition, legal provisions, the public attitude towards nature and landscape, political decision-makers and questions in respect of the future responsibility and ownership as well as the costs exert a decisive influence on the recultivation type. Moreover, recultivation planning should take account of the recultivated areas' integration into the surrounding virgin land.

4.5.1.3 Soil Science Aspects in the Reclamation of Ptolemais and Amynteon

The fact finding mission carried out in April 1994 was, inter alia, aimed at assessing the soil masses available for reclamation and subjecting them to a suitability test in view of future utilization. To this end, a total of 9 soil samples was taken, viz. primarily at the face, and investigated in respect of physical and chemical parameters.

The present mining and reclamation practice is marked by the absence of selective mining and dumping of reclaimable soil masses. So, it is pretty often that material from an approx. 100 m depth is used as the topsoil on inside and outside dumps. As a result of the geological conditions, however, the overburden materials have high magnesium and calcium carbonate contents so that the pH values are almost always varying between neutral and weakly alkaline ranges. In the majority of cases, even non selectively dumped overburden automatically gets green, thus preventing that these devastated areas remain barren of vegetation.

Soil Science Requirements as a Function of the Future Utilization

Decisive influence on the postmine use of reclaimed soils is exerted by the physical and chemical parameters of the materials dumped *[ATT 35 - 1/3]* . Depending upon what utilization is aimed at, the reclaimed soils have to meet rather specific requirements.

Intensive Agricultural Postmine Use

In the Ptolemais/Amynteon mining area it is not least due to the favourable site conditions that the agriculturally useful land is very intensively cultivated. The predominant cultivation is crop growing. But also sugar beets, potatoes and maize form part of the crop rotation. The sugar beets are partly sprinkled. In addition to the traditional agricultural cultivations, fruit growing (apples, pears, cherries, apricots, peaches and others) play a certain role. Depending upon the cultivation of the virgin soils, there will be high expectations in respect of the reclaimed sites' yield potential. What is more, only such areas will be used for agriculture on a long-term basis as are not turning into a marginal yield site as a result of reclamation quality.

In order to achieve a high yield capacity in respect of reclaimed soils, it is necessary to direct special attention to the soils' water holding capacity, aeration, and rootability. The thickness of the cultivable soil spread should be at least 1 m. This soil layer must be free from soil compactions, thus allowing the cultivated plants' roots to penetrate into the ground. Silty soil material with not too high sand contents has a positive effect on the useful water capacity.

The soils' rootability and aeration are predominantly influenced by the soils' grain sizes and degree of density. In order to avoid considerable soil compactions, special importance has to be attached to dumping and levelling of the soil material. The exacter dumping is adapted to the final relief, the lower the levelling expenditure. At the time of levelling, the soil material should be as dry as possible since a rise in the soil water content is also accompanied by a steep increase in the risk of detrimental soil compactions being involved. Investigations carried out in recent years into potential soil compactions on the Horemi/Megalopolis outside dump revealed raw densities of the soil that ranged between 1.8 g/cm³ and 1.85 g/cm³. They are the result of excessive levelling on soils with too high a water content. Such degrees of soil density do not permit any intensive agricultural utilization of the reclaimed areas since both water infiltration and rootability are impaired. Accordingly, these soil properties have an adverse effect on yield as well. In particular during the rainy periods, extreme compactions entail water accumulations on the soil surface, which will interfere with the uniform cultivation of the areas.

Success or failure in respect of the creation of agriculturally useful land substantially depends on the soil material that is dumped as the topsoil. Selective mining and dumping of separately allocated soil materials play a crucial role in particular during the creation of sites planned to have a high yield potential.

Extensive Agricultural Utilization and Forest Sites

Neither according to the demands made on extensive agricultural utilization (grassland, extensive cultivation) nor for forestry purposes need the reclamation and soil science-specific requirements meet the strict specifications valid for those sites that are planned to have a high yield potential. Under soil science-specific aspects, it is true, it is on the one hand advantageous if, e.g., the topsoil is dumped as exactly as possible and levelling on soils with water contents being as low as possible is minimized; on the other hand, however, not so great an importance is attributed to material selection under the conditions prevailing in Ptolemais/Amynteon. This is due to the overburden's high carbonate content resulting in a pH value of about 7.5. As a consequence, large areas in Ptolemais have got greened by themselves, large parts of which have not yet been subjected to final reclamation. In terms of water and nutrient supplies, grasses, herbs and forest plantations make more moderate demands on the soil. So, goal-directed reclamation measures (planting, sowing) will allow considerable reclamation successes to be achieved even with overburden materials extracted from greater opencast mine depths. If possible, selective fertilization measures are required to increase the soils' low nutrient content. In view of the development of any soil compaction, attention, however, is to be paid to the fact that the soil material will be levelled only with a correspondingly low water content since both grassland vegetation and forestry plantations are susceptible to compaction-related problems.

Summary and Suggestions in View of Future and Final Reclamation Measures

Although due to the bucket-wheel excavator technique part of the soil materials important to reclamation purposes are selectively mined, these masses, however, are dumped according to a completely non-selective scheme. The usually high carbonate contents of the overburden materials *[ATT 35 - 3: Samples 1 - 7]* permit this procedure since they prevent large areas from remaining barren of vegetation. Even areas that were exclusively dumped by means of stackers and where no selective reclamation took place get greened by themselves. In the Ptolemais/ Amynteon mining fields, these specific overburden and soil properties have contributed to the fact that selective mining and dumping of high-quality soil materials received hardly any notice.

Considerable quantities of soil materials that are excellently suitable for reclamation purposes occur in Ptolemais, and here in particular in the South Field *[ATT 35 - 3: Samples 5 - 7]* , and in Amynteon *[ATT 35 - 3: Samples 8 & 9]* . The contents of available nutrients, the humus and total nitrogen contents of the sites sampled correspondingly and shown in *[ATT 35 - 3]* prove these materials to be excellently suitable for agricultural reclamation. The browned overlying layers with a thickness of up to 10 m in the South Field occur over almost the total bench length and are a high-quality reclamation material. It is only at the upper end of the first mining level that due to the considerable change in material approx. 200 m have to be mined selectively. Of a particularly high quality is the upper, 1 to 2 m thick humic soil layer, which results from a formerly silted-up lake *[ATT 35 - 3: Sample 6]* (. Humic contents of 2.5 % and total nitrogen contents of 0.12 % demonstrate the excellent quality of this material. Even the nutrient supply level of this soil material is high. It is only exceeded by the sample *[ATT 35 - 3: Sample 7]* taken directly from the tilled soil.

On the one hand, it is necessary to underline the special suitability of this material for reclamation purposes, and on the other hand, it has to be pointed out that the soil as ecological good is of primary interest. Therefore, systematic reclamation measures have to be aimed at making particularly suitable soil material available for reutilization.

Generally, soil material settled in relief depressions is likewise of special interest to reclamation since nutrient and humic contents are also very high. Sample N° 2 *[ATT 35 - 3]* was taken in the zone in advance of the face of the Komanos opencast mine, where colluvium occurs with an approx. 3 to 4 m thickness.

Even material that was taken from greater opencast mine depths (South Field) and then analysed shows very favourable soil physical and chemical parameters -sample N° 3 *[ATT 35 - 3]*, second bench, South Field.

Sample N° 1 *[ATT 35 - 3]* was taken from a depth of 3 to 6 m in the zone in advance of the Komanos face. It was already there that the thixotropic character of this material was observed. The nutrient contents are low. Furthermore, the MgO content is also low, which is a further indication of this material's instability. It should not be used for reclamation.

In the Sector 6 area the soil conditions are similar to those of the South Field. What is lacking, however, is the thick humic topsoil so that an approx. 6 m thick layer is available for reclamation.

In the North Field, too, there are useful soil layers for reclamation, with the occurring thicknesses, however, being limited to 1 to 2 m. In addition, the sand and gravel contents of some partial areas are very high.

According to the soil analyses, the face at Amynteon that was sampled at a representative location also shows high nutrient and humic contents for both the topsoil -sample N° 8, 0 - 30cm *[ATT 35 - 3]* - and the bottom soil -sample N° 9, 30 - 250cm, *[ATT 35 - 3]*. The very good suitability of this material, too, (down to a depth of 4 to 5 m in some cases) for reclamation is unquestioned, all the more since it occurs over almost the total length of the mining side.

Questions in connection with mass disposition have necessarily to be left unconsidered, and this also applies to opencast mining aspects of the goal-directed transport of recultivable masses. The reason is the lack of knowledge of the local mining and dumping progress. In addition, account is to be taken of the fact that all areas not finally reclaimed call for a subsequent treatment by means of levelling. Here, it is assumed that due to the economic conditions and the scarcity of material, additional spreading with more suitable materials will be implemented only on partial areas. For the necessary mass transport, the trucks, which are anyhow used in both opencast mine areas, should be included as well. Small-sized areas with well suitable material could thus be mined and dumped selectively. Attention, however, should be paid to the fact that the trucks will be employed only during dry soil conditions (in the course of the summer months), since otherwise the areas finally to be reclaimed will get extremely compacted.

4.5.1.4 General Remarks on Recultivation in the Opencast Mine Areas

The entire recultivation area is located in a gently undulating landscape of river meadows which was predominantly used for intensive agricultural purposes before lignite mining. This means that the flat surfaces were mainly cultivated for arable farming, while the slope areas served as extensive grassland. These types of land use are determined by the site conditions, in particular by climate and soil. Due to the gently undulating relief, a large number of slopes and/or cliffs covered by trees and shrubs were produced along with settlement and the installation of traffic routes. In the east, steeper mountains and mountain ranges border on the mining field.

4.5.1.5 Recultivation Concept

The primary object of the recultivation concept is to create coherent useful agriculturally areas of the largest possible sizes. These can be located both on the outside dumps and on the inside dumps and/or on superelevated inside dumps. Major losses in useful agricultural land result in particular from the mining-related remnant lakes, their banks as well as from the dump slopes that cannot be used for agricultural purposes. But as to the useful agricultural land, it is to be considered here that recultivation permits both optimum plot designs for cultivation and the most favourable arrangement of the plots. In addition, there is the possibility of locating the larger agricultural operations directly within the recultivated area. Another aspect to be considered within the scope of recultivation is an optimum network of farm roads.

Based on the mining-specific underlying conditions and the recultivation measures already performed, we have developed a recultivation concept for the Ptolemais mine area which is enclosed as *[SCT 7.2.1 - 17]* and another one for the Amynteon mine *[SCT 7.2.1 - 18]*.

In area terms, the individual types of uses in the Ptolemais mine area are subdivided as follows:

Agriculture	5 979 [ha]
Forestry	3 218 [ha]
Water surface	1 613 [ha]
River meadows	778 [ha]
Former operational area for agricultural and forestry purposes	407 [ha]
Total	12 014 [ha]

For the Amynteon mine, the area balance is as follows:

Agriculture	1 678 [ha]
Forestry	1 345 [ha]
Water surface	1 345 [ha]
Former operational area for agricultural and forestry purposes	310 [ha]
Total	4 678 [ha]

The above area balances reflect the importance of agricultural recultivation.

The following is a description of the various recultivation types:

4.5.1.5.1 Agricultural Recultivation

With 5 979 and 1 678 ha agricultural areas account for the largest part of the recultivated land, which results mostly from the obligation to return the land. The agricultural areas were designed in such a way that even according to the latest guidelines corresponding yields can be achieved. The gently winding network of farm roads as a rule forms plots that are 300 - 400 m long. The soil material selectively extracted in the area in advance of the mine (loess, till), which is spread as evenly as possible with a thickness of 1.5 - 2.0 m on the raw dump and subsequently graded for agricultural use, offers the best conditions for optimum cultivation. The areas' inclinations should not exceed 1.5 - 2 % to reduce the risk of erosion.

The so called intercalations occurring in the excavation front as marl and till are a cultivable soil substratum which, provided it is mined separately and selectively, also constitutes an excellent recultivation material. A rough determination of the occurring cultivable substratum and the till contained in the intercalations shows that the useful areas planned for agriculture and forestry can be recultivated by means of that material.

These areas are suitable for both agriculture and grassland cultivation. If, as an exception, bad soil materials occur in the area in advance of the mine it is to be considered to what extent these materials should be dumped as overburden or whether they should be used to prepare useful agricultural areas, in the case of which extensive grassland cultivation must be preferred.

The farm roads including shoulder should not exceed a width of 4.50 m. To ensure appropriate long-term trafficability, appropriate subsoil is to be incorporated, if possible already within the scope of dumping operations.

To break up the monotony of the natural scenery and improve the biotope structure, certain biotope types are to be integrated into the agricultural areas. These could include, e.g., single trees, trees and shrub stands, rows of trees along the roads, alleys and other special structures, such as succession areas.

The agricultural areas and special cultures, such as fruit trees, established within the scope of recultivation in the last few years are marked by normal growth and yields. Also, both the farmers who had to surrender their own land for mining operations and the agricultural operations located near the mines have a high demand for new agricultural areas.

During the first few years, the agricultural areas should be cultivated by the mine operators and/or farmers working on behalf of the mine operators to ensure soil improvement and prevent the areas from being cultivated with the object of optimizing yields. It is in particular larger operations that should be immediately integrated into the useful agricultural area to permit an arrangement and equipment of buildings that is appropriate for a modern agricultural operation. The planning in respect of the siting of single farms and/or combinations of several agricultural operations should take early account of the development aspect including other infrastructural measures. There is the additional possibility of having the agricultural areas taken over by operations located in the surrounding area.

4.5.1.5.2 Forestry Recultivation

With a total of 3 218 and 1 345 ha, the forests mostly cover the slopes of inside and/or outside dumps and those of the remnant lakes. It is in particular in forest areas that relief design, soil substratum and vegetation lay the foundation for the most diverse uses and biotope structures. The slopes characterized by as flat as possible inclinations should be subjected to intensive cultivation, while the somewhat steeper slopes should predominantly be used to establish dry sites (exposed to the south). The wood species, p. e. pine, acacia, beech, oak, fruit tree, hazel, have proved excellently suitable for plantation in recultivated areas; if possible, they are planted in close systems to ensure as early as possible soil shading and thinning of the generally light-requiring weeds.

If possible, the areas are to be planted immediately after dumping in the subsequent planting period (autumn or spring) to avoid erosions and weed development to a very large extent. Here too, till has proved an excellently suitable cultivable material, with a certain stone content, such as gravelly material, having a definitely favourable effect.

The subsequent tending of these stands, viz. the consistent thinning of the solid stands, for several years is of particular importance to ensure optimum growth of the remaining trees.

A long-term area balance for the individual annual periods is required to have sufficient plant material available at the time of planting.

4.5.1.5.3 Water Surfaces in the Recultivation Area

A total area of 1 613 and 1 345 ha is planned to be established as water surface within the scope of recultivation. For erosion reduction, the final voids must be filled with water as soon as possible so as to prevent the slopes from eroding. Depending on the particular uses planned for such water surfaces, different bank inclinations and/or substrata are to be used. In particular in the wave attack zone the planned bank area should have a maximum inclination of 1 : 10 so that the wave's energy is reduced. Besides inoculation with aquatic and amphibian plants, shrubs and trees should be planted above all in the area subjected to wave attack. The shrubs and trees could possibly be planted some years before the planned final water level will be reached to allow the banks to stabilize thanks to the formation of roots. These remnant lakes could be supplied with water either from the Solou creek or by the slowly rising ground water, or via drainage ditches discharging their water into them.

In addition to the water quality, it is the bank design and the planned infrastructure in the slope areas which play an important part with respect to subsequent use and function. At this point in time, however, it is not yet possible to make any statements on the extent to which these water surfaces to be newly created will also be accepted and used by citizens in search of recreation, e.g. for swimming, boating and other aquatic activities.

Should the water surfaces be intended for intensive local recreation, a concept would have to be set up stating the degree to what all or only some water surfaces will be made available for that purpose. In addition, the required infrastructure (road connections, parking places, hotels and restaurants, bathing facilities, etc.) would have to be developed.

4.5.1.5.4 River Diversion with River Meadows

A special element shaping the landscape is the river meadows to be created within the scope of dumping operations. The river itself and the river meadows belonging to it should, if possible, be provided with those elements they would develop naturally. Particular attention is to be paid to this flow regime's own dynamic, such as the formation of steep banks or floods. In addition to forest areas with river meadow shrubs and trees, free areas should also be integrated, e.g. as meadows or wild herbs.

4.5.1.5.5 Surface Drainage of the Recultivation Area

The surface water is properly drained off into the ditch systems installed for that purpose and then discharged appropriately. These ditches should be approx. 1 m deep; different slope inclinations and partly interrupted or sporadic vegetation of suitable shrubs and trees make these ditch systems important landscape elements.

In the past, the element 'water' was usually considered a dangerous element so that every effort was made to discharge water as soon as possible. This situation is much different today when the element 'water' is understood to be an element of life and everything possible is done to keep the water as long as possible in the recultivated areas and discharge it, if necessary at all, in doses into the rivers. Besides the creation of wet and/or humid sites, water constitutes the ideal element of life for species from unicellular organisms all the way to large mammals and multifarious vegetational types.

4.5.1.5.6 Landscaping Elements, Biotope and Species Protection Measures

Landscaping elements and special biotope sites are also to be integrated into the areas to be recultivated for agricultural and forestry purposes. In agricultural areas, landscaping elements, grass strips along the roads, single trees and shrubs, alleys, rows and groups of trees, etc. are suitable elements structuring and shaping the landscape. During planting, adverse effects on agriculture are to be avoided; shrubs and trees, e.g., should be arranged in such a way that as much shade as possible is cast on the roads. Moreover, the useful agricultural areas should only be lined by shrubs and/or shrub-like trees. Some landscaping elements are particularly suitable in those cases where residual plots are produced within agricultural areas which cannot be used optimally for agriculture.

In the forests, too, certain areas -if possible far away from footpaths and forest roads- are to be established as special sites, e.g. succession areas and humid biotopes. In some places, the usual cultivable soil substratum should be dispensed with and instead gravelly and sandy areas should be created deliberately. It is in particular these sites which constitute ideal conditions for the development of thermophilic species of insects and plants. Within the slope areas, too, such special biotopes are to be created, with sites exposed to the south being especially suitable.

With this recultivation concept, the attempt is made to allocate major part of the recultivated areas to agricultural uses. To this end, the dumps, viz. both outside and inside dumps, are designed as flat as possible with a specific general inclination. This applies in particular to outside dumps, with account also being taken of the fact that a larger area may have to be used for the outside dumps. In this part of the landscape, recultivation will produce a mosaic of useful agricultural areas, wooded slope areas and larger water surfaces including the green zones belonging to them.

4.5.1.5.7 Recreation/Infrastructural Measures

The entire landscape offers favourable conditions, in particular for extensive recreation. The alternation of water surfaces, slope areas, forests and useful agricultural areas and the diverse network of mostly winding farm/forest roads provide optimum possiblities of extensive recreation. The extent to which further measures aimed at intensive recreation should also be considered in the future, cannot be determined at this point in time. This would require the integration of corresponding infrastructural measures.

4.5.1.5.8 Traffic Routes (Roads, Footpaths, Farm/Forest Roads, Railway)

The entire area is to be developed by a well-designed network of farm/forest roads which can also be used by hikers. Roads should continue to be minimized in the future in order to largely avoid intersecting effects. The railway line to be installed in the recultivated area within the Solou ceek meadows should be routed in such a way that there, too, the separation effect is reduced to a minimum, e.g. by installation of pipes below the railway line.

4.5.1.5.9 Other Areas (Former Mine Facilities)

In addition to the recultivation of land used for lignite mining, those areas affected outside the actual opencast mines have also to be landscaped appropriately and recultivated properly at the end of operations. These areas are, e.g., those of former administration buildings, operational facilities, bunkers, access roads, and railways.

To optimize the natural scenery, the transitions from virgin to worked land should partly be designed in a near-natural way. In this context it cannot be excluded that part of the virgin land will also be covered by dumps or used for other purposes.

4.5.1.6 Conclusions & Recommendations

The implementation of this recultivation concept will lay the foundation for the development of an ecologically intact landscape so that after some years you will no longer notice that it will have been created by man. In particular the enrichment of the landscape by elements such as water surfaces, near-natural slope areas, the comparatively undulating relief of near-natural river meadows form the backbone of a landscape which can be used intensively and is also suitable for recreation; here, biotope and species protection is given equal priority.

This is a concept permitting a high degree of flexibility, should the underlying conditions change. Implementation of this concept calls for further detailed planning. Furthermore, surface drainage and hydraulic systems still have to be planned in detail, which is appropriate to be developed, only if the relief is likely to be laid out as specified in the plan or in a similar way.

Along with a respective detailed planning, the planting tests already started and the cultivation of the useful agricultural areas should be continued.

4.5.2 Environmental Impact on Surface Water Bodies

Adverse impacts on surface water bodies have so far been limited to minor relocations of the course of the Soulou creek and a possible decline of baseflow to, and a thorough pollution of, this small stream. Further relocations will become necessary until the stream will ultimately be relocated on inpit dumps of existing and possibly future mines of the basin. The full impact of ground water withdrawal for Amyntaion Mine on Lake Chimaditis and the Amyndas Channel connecting this lake with Lake Petron will probably become notable in 1995. The decline of the ground water table in the aquifer system below Lake Chimaditis is likely to result in a complete disappearance of this lake for several decades and in a reduction of runoff in the channel towards Lake Petron. That is to say, Lake Chimaditis has already suffered from previous efforts to reclaim farm lands by draining the formerly swampy lands just downstream of it. A remedial measure to prevent this could entail the discharge of water from dewatering wells to infiltration wells just downstream of this lake to create a ground water barrier which prevents the cone of depression around the mine from spreading futher outward beneath the lake bed.

Should it become necessary to withdraw ground water from the karstic basement beneath Amyntaion Mine, the water level of Lake Vegoritis would certainly more affected than it is already now. A possible way of alleviating this additional impact could consist of discharging this karstic water back into the Lake to stabilize its level.

4.5.3 Impact of Ground Water Control Measures

Mine dewatering measures are usually accompanied by a more or less heavy environmental impact, resulting from the total destruction of overburden aquifers within the bounds of an opencast mine, from a substantial loss of ground water in storage in aquifers around the mine, and from a depressurization of confined aquifers even at large distances away from the mine. Is it obvious that the recovery of lignite in a mine and the protection of ground water resources represent divergent interests which both have strong arguments in their favor. Necessary are compromises taking into account the justified interests of both sides.

Given the short time of large scale ground water control operations at Amyntaion and Southfield Mines, a severe environmental impact has not yet been recorded but is likely to become apparent in summer 1995. Shallow irrigation wells in the large farming areas to the east of Lake Chimatitis and to the south of Southfield Mine will gradually fall dry due to the lowering of the regional ground water tables. In a first phase, this development will lead to deepen the wells and to lift water from greater depths. So higher costs incur. With the mines deepening and expanding, the aquifers will partly depleted and partly destroyed, and irrigation farming might even come to a end.

Even more severe could be the environmental impact if it could become necessary to drill wells into the basement of Amyntaion Mine to lower the head in the karstic aquifer below the mine. As it is very probable that this basement block is hydraulically part of the Lake Vegoritis System, any substantial depressurization at Amyntaion might be followed by a decline of the lake level. To prevent this, the water discharged from the deep karstic wells would have to be piped back into the lake. Whether or not this scenario is realistic, is not yet known at the moment. But the possibility is real and relevant investigations are overdue to be carried out.

Comparable investigations have to be conducted to establish the environmental impact of dewatering measures for the proposed Florina Mines.

It will furthermore become necessary to predict the hydrogeologic post-mining situation in both undisturbed basin sediments, in inpit dumps, remnant holes and in the karstic areas. Prerequisite is the availability of a powerful numerical ground water model and a comprehensive data base.

Both data base and model in turn require the existence of a hydrologic monitoring system which must be seen as integral part of the mining process. Ground water monitoring includes sinking of piezometers into the different aquifers, water level recording at regular intervals of time, evaluation of the recorded data in form of hydrographs and water table maps, collection of hydrochemical analyses, measuring discharge rates of natural springs along the mountain fronts surrounding the basin, assessment of pumping tests results, evaluation of rainfall records etc. Many of these data have been and will be collected by other agencies and institutions such as IGME, the National Meteorological Service, and universities. A quite comprehensive summary of pertaining work, executed up to the eighties, is given in the doctoral dissertation of Pavlakis *[SCT 7.3 - 29 - 0]*.

Technically it is impossible to distinguish between work dedicated to mine water control measures and environmentally related work. This implies that no special staff will be required. Experts being in charge of water control activities will thus also be responsible for environmental activities.

4.5.4 Longterm Impact of the Hydrological Situation

The longterm outlook can now be characterized by an accumulating loss of ground water, initially stored in aquifers, and surface water, stored in the lakes of the Basin of Florina - Ptolemais. Both mines with dewatering needs and power plants, consuming water for cooling purposes, are responsible for this situation. Other users such as agriculture have been able so far to mask their rates of withdrawal of ground water or diversion of surface water by not monitoring the discharge rates.

Taking into account previous, present, and possible future developments, the water deficit will continue to rise until the decade of 2035 - 2045, when the last LCPA mine is scheduled to close down (Mining in the Florina Sub-Basin is likely to continue for some time after).

The impact of mining on water bodies can be expressed as

- full or partial depletion of unconsolidated rock aquifers around mines as Amyntaion and Southfield,
- depressurization of karst aquifers (possibly in Amyntaion and Florina Mines)
- shrinking or even drying up of a lake as Lake Chimaditis and shrinking of a lake as Lake Vegotitis.

With the end of pumping operations both for mines and power plants, the technically achieved equlibrium between natural recharge to aquifers and lakes and man-induced discharge breaks down and a period of an hydrologic unequilibrium begins. Triggered by the elements of hydrologic cycle, a general recovery is to begin which is controlled by the boundary conditions of the existing hydrologic systems and the rates of recharge by infiltrating rainfall and lateral inflow of water to aquifers and lakes. Locally, the creation of inpit dumps and remnant voids, which are to become lakes, will have notably changed former topographic and hydrogeologic features.

So far, there is still a profound lack of information on both regional and local hydrologic conditions of the region. For the time being, it is impossible to foretell if it will take centuries or only decades until a new hydrologic equilibrium will be reached. It is as well impossible now to predict if this new "natural" equilibrium will be acceptable to the population of the mining district.

So it will become necessary for PPC to control the events of the postmining period to finally achieve an acceptable result. Appropriate controls will be costeffective, and PPC will be obliged to make corresponding provisions during the years to come. Before doing this, long-term planning data including water figures must be known. This stresses once more the need to gradually develop ground water models which need input data that are not yet or not sufficiently accurately known.

It is believed that the main factors, controlling the regional hydrologic situation, are the huge karst aquifer systems, out of which three have already been identified during the last three decades:

1. the block of the southern Vermion Mountains with a general water table elevation of about 340 m a.m.s.l., forming the basement beneath the southern mines of LCPA,
2. the block of the northern Vermion Mountains with a general water table elevations of about 515 - 520 m a.m.s.l., with Lake Vegoritis as a prominent feature, and Amyntaion Mine located above its subcrop in the northwest,
3. the block of the southern Voras Mountains with a general water table of 570 m a.m. s.l. and above that elevation, with Lake Petron as major lake, also forming the basement of the Florina-Sub-Basin.

A principal question will be for the source of water that will be used to fill the gradually appearing remnant holes of the mining district. Can it be provided by gravity flow from the Voras Mountain Block - this being the least costly solution? Or must it come from other sources - a supply from the Aliakmon Reservoir certainly the least desirable choice. Will the lakes become stable elements in the postmining landscape, given the climatic conditions of the region?

None of the questions, pertaining to the development of the postmining landscape can as yet be answered. They have been raised in this section to show that dealing with water is to become a decisive part of PPC's planning process. In addition to the work of the expanding Geotechnical Department of DAO, governmental institutions as IGME and the National Meteorological Service as well as technical universities must be included in the process of se-curing the data base. Section *[SCT 1.2.2]* of this report shows what kind of work will become necessary to obtain the required answers.

4.5.5 Ash Deposition and the Future Groundwater Quality

The influence of ash depositions is an area of concern in other lignite centres abroad.

Techniques of depositing ash and other waste products in especially prepared landfills within dumps of waste rocks as required by the authorities in Germany will not be necessary in the Amyntaion - Ptolemais Mining District.

Reasons for this statement are given below:

The lignite fired power plants in the Rhenish Lignite District produce boiler and fly ash, gypsum, and water, containing high concentrations of NaCl.

Gypsum and sodium chloride are waste products of the so-called wet desulfurization process which removes SO_2 from the flue gas. Authorities have set maximum concentrations of sulfate (= noncarbonate hardness), chloride, and other chemical compounds in ground water leaving the dumps, which cannot be met if the waste of powerplants would be dumped along with the waste rock ftom the mines.

These waste products are homogenized on the premises of the power plants, transported by conveyor belts to special clay lined landfills within inpit and expit dumps of some lignite mines and deposited. Homogenization of the mixture ensures that chemical reactions involving the reactive alkaline-earth oxidesof fly ash, gypsum, sodium chloride, and water take place that produce new minerals like ettringite and others.

This mineral growth is accompanied by reduction of porosity in the dumped mass and by an also resulting decline of its hydraulic conductivity. Upon recovery of the ground water table in an inpit dump with such a landfill, the fill will become saturated. But its extremely low hydraulic conductivity ensures that the general flow of ground water in the dump will be around this landfill so that only a very small rate of contaminated water leaving the latter will come in contact with the ground water. Dilution will reduce any excessive concentrations of sulfate or chloride of the fill effluent to acceptable levels.

Here again, PPC is in the fortunate situation of not being required to adopt this or a similar solution even if the power plants should be equipped with desulfurization devices. Contrary to the situation in the Rhineland, the waste materials are mainly impermeable. The rate of solution taking place in the ash - waste rock mix will thus be so low that no harmful effects on the quality of ground water leaving the inpit dumps must be expected.

PPC is thus advised to continue with their present technique of dumping ash from the power plants along with the waste rock from the mines.

4.5.6 Dust Protection Measures

Another environmental aspect is dust suppression. The most important measures in this context are shown in *[ATT 35 - 04]*.

4.5.7 Noise Protection Measures

Whenever an opencast mine approaches a village or city noise protection measures can improve the acceptance of the mine.

There are three options to achieve a reduced noise immission:

- Noise emissions of the mine equipment can be reduced by technical improvements of the equipment itself.
- Inevitable emissions can be reduced by secondary measures as noise protection capsules e. g. for the gear boxles of excavators spreaders and belt conveyors.
- Noise protection walls or earth dams between the mine and a village or can contribute to the reduction of the noise immission.

A more detaied description of measures as such is given in *[SCT 7.3 - 30 - 0]*.

4.6 Personnell - Personnell Training

Detailed proposals for the organisational structure and for the training of PPC s personnell have been submitted by the Thalis Symphonia project including mine planning.

The longterm guidelines of the TMMP must be made effective by mid and short term planning activities which are to be carried out regularly according to these guidelines. The necessary skilled personnel for these planning activities is not available in PPC s mines.

The Implementation of the so called internal planning units in PPC s mines is a precondition for the execution of the TMMP.

5 Cost Estimates And Economic Analysis

The objective of the following section of this report is the cost calculation.

The production costs of each mine and for the total lignite production of PPC during the perios of time until 2020 are to be determined.

5.1 Summary of the Economic Analysis

The economic assessment was carried out according to the following subdivision :

PPC Mines
- LCPA Mines
  - Amyntheon
  - Sector 6 & West Field South
  - West Field North
  - North Field
  - Komanos
  - South Field
  - General LCPA
- LCM Mines
  - Horemi
  - Marathousa
  - Kyparissia
  - General LCM

All future expenditure were estimated to determine the total expenditure of each mine over the envisaged time period, not including the cost of financing.
The depreciation of new investments and future replacements have additionally been determined.

Over the lifetime of the project the specific cost per tonne of lignite resp. per Gcal (on base of the future expenditure) on price base as of 1995 will accumulate to:

Total Expenditure

	DRS / t	DRS / Gcal
PPC Mines	2 064	1 727
LCPA Mines	2 225	1 782
Amyntheon	2 573	2 322
Sector 6 & West Field South	2 095	1 615
West Field North	2 683	2 051
North Field	1 520	1 148
Komanos	3 428	2 791
South Field	1,610	1,282
General LCPA	233	187
LCM Mines	1 474	1 471
Horemi	1 086	1 095
Marathousa	3 135	3 135
Kyparissia	1 236	1 192
General LCM	175	175

(Not Escalated, duties and taxes, interest, and amortisation are not considered, constant exchange rate)

For details see tables *[ATT ????? -]* 4-1 to 4-5.
Tables*[ATT ????? -]*4-6 to 4-16 list the summarised costs subdivided into cost types for the main cost areas annually and for the total, while table *[ATT ????? -]*4-17 to 4-30 show the annual costs for each mine during the lifetime of this project.

The total expenditure are covering all reasonable expenditure for investments, replacements, labour, parts, contractor services, energy, and consumables as determined in this study. As advised by PPC duties and taxes are not applicable.

Costs were derived from:

- cost data provided by PPC,
- actual quotations from manufacturers,
- prices known from recently placed orders for similar equipment,
- operating experience from similar equipment world wide.

All cost figures in this analysis are in Greek DRS. They are on price base as of 1995 and were not escalated for the following years.

The exchange rate of

1 DM = 156 DRS

was kept constant over the total time period of the project.

The risk of cost overruns has conservatively been limited by the inclusion of 10 % contingencies for all cost types.

Termination point for the study and thus for the cost estimation is the transfer point at the end of the lignite conveyor, leading to the stockyard of a power plant, but including the transporting and dumping of the ash volumes coming from the power plants.

5.2 Assessment oft he Costs

The cost assessment has been executed as follows.

5.2.1 Subdivision into Major Cost Areas

The total costs have been determined for the major cost areas listed below.

5.2.1.1 Bucketwheel Excavators

All types of bucket-wheel excavators have been summarised in this cost area, although the operating cost have been estimated carefully for each type separately.

5.2.1.2 Spreaders

All types of spreaders used in a mine have been comprised in this cost area.

5.2.1.3 Conveyors

The width of the conveyor lines operated in the different mines ranges from 1000 mm up to 2400 mm.

5.2.1.4 Personnel

This cost area summarises the total expenditure for wages, salaries including employers on cost like taxes and insurances. A subdivision was made into operating and maintenance labour.

5.2.1.5 Other Equipment

This item comprises the costs of :

ground dewatering
surface dewatering
conventional equipment
auxiliary equipment
mine cars and
train transportation.

It was adopted, that the conventional equipment, which is mainly used to remove the hard layers, will be operated by contractors.

5.2.1.6 Other Facilities

Other facilities include the costs for the mine service facilities, the power supply, the control and communication equipment and the workshop equipment.

The operating costs for these facilities represent the cost of maintaining the machinery, equipment, and tools of the workshop, e.g. cranes and forklifts, and the office equipment.

5.2.1.7 Land Acquisition

The cost of one square metre has been assessed to DRS 250. The item land acquisition covers the future demand of land for the mines.

5.2.1.8 Reclamation

The preparation of the final landscape including agricultural and forestrial reclamation has been estimated to 465 DRS per square metre.

5.2.1.9 Resettlements

This area covers the cost for resettlements of houses and other buildings as well as the compensations for their inhabitants.

5.2.1.10 Relocations

The proceeding mines will reach rivers, roads, overhead power lines, and railways in the future. Bucket-wheel excavators, spreaders and conveyors will be transported; material distribution centres and mine service facilities have to be relocated resp. demolished and rebuild again. The costs which will arise by these measures are summarised in the cost area relocations.

5.2.2 Investments and Replacements

According to the scope of work the future investments are to be determined.

5.2.2.1 Determination of Investments,Methodology

Investment and replacement cost were estimated in detail for the following equipment according to the subdivision into cost centres.

- Conveyors 1200 mm
- Conveyors 1400 mm
- Conveyors 1600 mm
- Conveyors 1800 mm
- Conveyors 2400 mm
- Land Acquisition
- Auxiliary Equipment
- Mine Cars.

They represent the additional investments in equipment ready for operation as well as all major replacements during the lifetime of the mines.

They include the costs of transport, erection, and commissioning. A further allowance has been made for initial spare parts and consumables inventory.
Residual values at the end of equipment's economic life or the mine life are disregarded; No costs for the dismantling and removal of equipment were considered because it is supposed, that the salvage values will cover those expenditures.

Moreover the investment cost include additionally an allowance of 10 % for contingencies.

5.2.2.2 Depreciation

The following annually rates of deprecation have been given by PPC :

- Bucket-wheel Excavators 20 %

• Spreaders	20 %
• Belt Conveyors	20 %
• Conventional Mining Equipment	20 %
• Auxiliary Equipment	20 %
• Mine Cars	20 %
• Civil Works	12 %
• Buildings	5 %

The depreciation shown with table *[ATT ????? -]* 4-31 represent only that equipment which will be purchased in the future.
Especially the depreciation of the actual remaining book value of PPC was not considered.

5.2.3 Determination of the Operating Cost

The operating costs are to be calculated as stipulated in the scope of work

5.2.3.1 General Matters in Context with Operating Costs

Operating cost were derived on a year by year basis subdivided into the following cost types:

Labour costs were subdivided into operating labour and maintenance labour. They include all wages, allowances and benefits, and employer's on-cost like taxes and insurance.

Fuel shows the cost of diesel and petrol consumption and power the cost of power consumption.

Material and services cover all supplies, consumables, e.g. oil and grease, spare parts, and outside contractor services.
Additionally an allowance of 5 % has been added for transports of all supplies.

An allowance for operating contingencies has been considered with 10 % on all operating costs.

5.2.3.2 Non-Labour Cost

The non-labour cost contain fuel consumption, power consumption, material and services. Within these items the following price rates were considered :

- Diesel 104 [DRS / litre]
- Electric Energy 10 800 [DRS / MWh]

(all price rates are based on 1995 as advised by PPC)

The non-labour cost were assessed by multiplying

a chosen reference unit for each type of equipment or plant (mostly operating hours)

by an estimated consumption rate times price rate or a cost rate.

The reference units chosen are mostly the corresponding operating hours of the equipment. In the case of belt conveyors a cost rate and a consumption rate per operating hour and kilometre was chosen which reflects the cost to run one kilometre of the belt conveyor for one hour.

This approach allows the actual usage of the equipment and changing lengths of the conveyors to be considered correctly.

For vehicles the reference units are the kilometres driven.

In a few instances, simply a lump sum was fixed to assess the non-labour cost. In this case the lump sums reflect the maximum yearly non-labour cost of the corresponding cost centre. According to the actual utilisation of the equipment, the lump sum was adapted year by year.

The estimated quantities of the reference units are generally derived from the production schedule and machine capacities. The required operating time of support equipment is dependent from the operating hours respectively operating hours times kilometres of the corresponding equipment that they support.

5.2.3.3 Labour Cost

The labour cost were calculated year by year for all types of equipment and facilities. They are subdivided into operating and maintenance labour cost.
In year 2000, a year in which all mines are operating , the total required manpower amounts to:

Manpower in the year 2000

Cost Area	Operation	Maintenance	Total
PPC Mines	4 594	2 351	6 945
LCPA Mines	3 852	1 935	5 787
Amyntheon	493	177	670
Sector 6 & West Field South	647	249	896
West Field North	364	131	495
North Field	273	107	380
Komanos	331	130	461
South Field	1 012	345	1 357
General LCPA	732	796	1 528
LCM Mines	742	416	1 158
Horemi	354	142	496
Marathousa	115	47	162
Kyparissia	119	48	167
General LCM	154	179	333

[ATT ?????? -] 4-32 to 4-34 show the required manpower for operation, maintenance, and the total on a year by year basis for each mine.

The annual manpower was calculated on base of the results of the Thalis Synphonia Project and adapted to future needs.

As advised by PPC the labour cost were established as follows:

Labour Cost per man and hour

Category	Description	[DRS /h]
1	Managers, Engineers	4,110
2	Technology Graduates	3,450
3	Applied Science University Graduates	3,262
4	Skilled Workers, Operators	2,900
5	Semiskilled and Unskilled Workers	2,200

As already mentioned, the above labour cost include all wages, allowances, benefits, and employer's on-cost like taxes and insurance.

According to the level of accuracy of this study an average labour cost rate per man and year was established. Considering the distribution of categories within a mine and the effective working time of

1,840 hrs / year for mines and
1,805 hrs / year overall

the uniform rate of

5.928 million DRS per man and year

was used.

5.2.4 Overhead Cost

As advised by PPC a uniform rate of 9.2 % of all operating costs (excluding investments and replacements) has been used to cater for the overhead costs which are not chargeable direct to the mines (offices and expenses in Athens).
This percentage does not include interest and amortisation.

5.2.5 Levelized Unit Cost

To consider the different time periods of expenditure and revenue, the revenue requirement method was used to calculate the levelized unit cost.

Annual costs and lignite volumes are discounted by a certain interest rate;
the accumulated discounted cost amount divided by the accumulated discounted lignite amount results in the levelized unit cost.

Since escalation for costs was not considered, real interest rates have to be used.
The result in DRS / t is that levelized price which would enable an even result for the company over the total time period envisaged.

Or in other words : If the company would get that levelized price for the lignite over the total time period envisaged, the internal rate of return is the chosen interest rate for discounting.

5.3 Comparison of Results

As table *[ATT ????? -]* 4-1 to 4-4 show, there is a strong dependency between the total specific costs per tonne of lignite resp Gcal and the waste : lignite ratio. But the figure gives more information: Although the waste : lignite ratio of Amyntheon and Sector 6 & West Field (South) are comparably high, their specific cost do not correspond to the ratio.

The utilisation of the main mine equipment (excavators, spreaders and conveyor lines) is another cost influencing factor, which is to be tken into account
A similar situation can be observed referring to Horemi or Marathousa. The specific costs of Marathoussa are very high despite the moderate waste : lignite ratio compared to Horemi. The reason for that is the extremely low utilisation of the main mine equipment, which does not reach half of that in other mines. Kyparissia has also very low utilisation factors, but they are compensated to a certain extent by the very good waste : lignite ratio.

For the South Field we realise a totally different situation : Although the waste : lignite ratio is moderate and the utilisation is low, the specific costs of lignite are comparably low. In that case the economics of scale are responsible for a major part of that result. The lignite production of that mine is more than twice higher than all other mines and the South Field mine operates large sized main mine equipment only.

5.4 Alternative Energy Sources

To compare competitive energy alternatives, it has to be considered, that they also must be qualified to be used in base load power plants like the lignite. This does not apply to natural gas, which is normally used for the production of medium or peak load electric energy.

For the time being the price of imported black coal amounts to

1,800 - 2,000 [DRS / Gcal]

(At a major sea harbour). Considering the transportation costs to existing or possible future power plant sites, this energy price is to be compared to the price of lignite based calorific energy as supplied to the lignite fired power stations. According to the cost calculation in this report this price is:

1 727 [DRS / Gcal].

PPC s lignite is lignite is a competitive source of energy for the production of electric base load energy at present.

Because imported black coal is a strong competitor for the german lignite the future development of the price for this source of energy has been investigated *[SCT 7.3 - 25 - 0]*. This analysis results in a price for imported black coal of

166 [DM / t SKE] -206 [DM / t SKE].

for the year 2010 (At a major german harbour). A ssignificant increase of theprice of imported black coal is expected.

There is a considerable potential for reductions of the cost of PPC lignite as calculated in this study:

- The remaining reserves and the mining ratio have been assessed conservatively due to the lack of accurate deposit information. We expect the follow up activities inthis field to result i increasing reserves and decreasing mining ratios.
- The utilisation of PPCs main mine equipment has been set close to its lower limit.

Additionally a higher utilisation of the lignite fired power stations could contribute to a lower price of the lignite based electric energy.

Taking into consideration the future evolution of the price for black coal and the aforementioned potential of reductions of the price for lignite based electric energy in Greece PPC s lignite centres are expected, to keep their present market position in future.

6 Conclusions & Recommendations

This final section of the report comprises recommendations for the future actualisation of the Technical mine Master Plan and for follow up activities, which are to be carried out, in order to execute the long term concept of development of the TMMP.

The proposed activities can be assigned to the organisational units proposed in the Thalis Symphonia Project. These units are an external unit (Outside of the mine hierarchy) dealing with the long-term concept of development for all PPC mines together (DAO). The future actualisation of the TMMP is to be executed in this organisational unit.

Additional mid- and short-term planning in the so called internal units (Planning units within the hierarchy of the mines) are necessary. The objective of these activities is, to adjust the mid- and short term plans of development for each mine to the long-term concept of development (Inevitable deviations between both concepts are to be removed regularly) and to add the planning details, which cannot be determined in the long-term planning.

Accordingly the following subjects are described:

- Follow up activities of the external unit (DAO),
- Follow up activities of the internal units (Mine planning units in the mines).

The remaining Masterplan Team, which is completing the TMMP at present, is familiar with the problems to be solved. Its project manager was involved in the organisational aspects, which have been dealt with in the phase II of the Thalis Symphonia project and in the preparation of the TMMP. It is suggested to use this group for the execution of the proposals listed below in co-operation With DAO and the internal mine planning units, to be installed in the mines within the ongoing Thalis Symphonia project.

6.1 Follow up Activities of the External Unit (DAO)

There are three essential items of input for the preparation of the longterm concept of development for PPC s lignite mines. These items are:

- The lignite demand,
- the relevant deposit characteristics (Waste and lignite reserves, lignite quality, mining ratio, quality parameters for the strata with out analysis),
- the utilisation of the equipment capacity,
- lignite sampling and analysis

The external unit is to deal with each of these three items in future

6.1.1 The Lignite Demand

The longterm proposal for the lignite demand applied at present is not regarded as the final approach for several reasons.

The present proposal for the long term evolution of the total net generation in the Mainland grid of Greece has been determined by the numerical analysis of the actual generation figures observed in the past. An analysis as such is to be actualised regularly and the erection of additional power station capacity is to be steered accordingly.

The requirements of base load capacity on the one side and of medium- and peak load capacity on the other side are especially important in this context.

As we see it, too much base load capacity has been installed in the past. At present the base load power stations are in the position, to achieve sufficiently high utilisation factors. In the future too much base load capacity is possibly installed again and the utilisation of the base load capacity is reduced correspondingly.

This is likely to apply to the original schedule proposed by PPC s Direction of Programming and Strategic Planning. It does, however, not yet include the decommissioning of units in the LCPA and the LCM, which has been proposed by the Masterplan team according to the remaining lignite reserves in PPC s deposits.

The remaining reserves have not yet been determined finally. The status of the geological interpretation (See 6.1.2) is the reason for some inaccuracy to be removed in future. A considerable potential, to increase the reserves, is the application of „other fuels" with a higher calorific value in addition to PPC lignite (See 6.1.2).

It might be necessary, to replace a fraction of the base load capacity in PPC program for the expansion of the power station capacity by medium and peak load capacity.

The investigations described above, which are to be carried out by DAO in co-operation with PPC s Direction of Programming and Strategic Planning and with the Division of Production are expected to result in a changed lignite production schedule for the mines.
As a consequence of these changes a review of the longterm concept of development for PPC s mines will be necessary in certain distances of time.

6.1.2 The Relevant Deposit Characteristics

The remaining reserves, the lignite quality and the mining ratio have not been determined finally in the Technical Mine Master Plan.

A certain inaccuracy of these figures is to be accepted for long term activities in any case. A deposit is normally completely explored after it has been exploited. In the LCPA and in the LCM this accuracy of the deposit information is, however, not sufficient at present.

Major influences on reserves and ratio are expected by the missing correlation of the strata in the deposits. This influence is related to an improved geometrical representation of the mineable lignite seams. Additionally the quality parameters of the so called layers without analysis, which had to be set in a very conservative way at present, can be substituted by the quality figures of the corresponding layers in other neighbouring drillholes.

As a consequence of the results of geotechnical investigations, which are pending at present.

increasing reserves will possibly be related to the review of the safety pillars around the Kardia- or Ptolemais- and Liptol power stations. These saflety pillars have been set very conservatively. The present status of the geotechnical investigations forced us to do so.

The investigation of the perimeter slopes in the mines might result in reductions of the reserves in some cases. This applies especially to the western perimeter of the two parts of the West Field. These slopes are located at the perimeter of the Ptolemais deposit. In this area strata dipping down towards the mine and faults dipping down in the same direction are to be expected. At the same time a public road and a railway line atop the slope are to be protected.

The necessary geotechnical analysis calls for the co-ordinated action geologists, hydrologists, geotechnicians and mine planners. The co-ordination of the activites schould be assigned to DAO from our point of view.

A considerable influence on the remaining reserves and on the mining ratio can be expected by the application of „other fuels" with a higher calorific value compared to the PPC lignite.

The mixture of both fuels must correspond to the consumers specification. Blending the lignite with another fuel, which is characterized by a higher calorific value allows for a reduction of the calorific value of the lignite. If, however, a lower calorific value of the mine production is acceptable, exploitable reserves of thermal energy will increase and the mining ratio will decrease according to our experience achieved up to now during the preparation of the Technical Mine Master Plan and in other projects. This applies especially to mine fields, which are located close to the perimeter of the total deposit, where thinner lignite layers and thicker intercalations are to be expected (Both parts of the West Field).

We learnt, that PPC regards the application of imported fuels as less favourable in this context. There is, however, a possibility to achieve the effects described above without the application of imported fuels.

In the case of the Liptol and Ptolemais power stations a lower calorific value of the mine production can be accepted, if dry lignite from the Liptol briquetting plant is supplied not only to thw Liptol- but also to the Ptolemais power station according to a proposal by the LCPA. In a second step this procedure is proposed for the Kardia power station as well. The strong influence of small reductions of the acceptable calorific value of the lignite production of the West Field South on the exploitable reserves and on the mining ratio has been shown. There are two options to achieve the necessary drying effect for a fraction of the lignite supplied to the Kardia power station. The power station can be equipped with steam separators (As the megalopolis power stations) or a separate lignite drying facility is to be installed.

Up to now the quality of the intercalations in unknown.in a multi layer deposit as in the case of PPC s deposits the reserves are, however considerably influenced by the quality of the intercalations. It is suggested to start an investigation of this matter as soon as possible.

This activity requires the co-ordinated action of mine planners and Power station expearts. Ist co-ordination should be assigned to DAO from our point of view.

6.1.3 The Utilisation of the Mine Equipment

The utilisation of the mine equipment is hampered by inappropriate design features at present (lack of theoretical capacity, lack of drive power). The planning of appropriate remedy measures and the procurement of spares needs possibly the support of DAO and co-ordination activities.

6.1.4 Lignite Sampling and Analysis

In order to avoid lignite losses and problems related to insufficient lignite quality in the power stations, the selective mining of lignite and intercalations needs to be monitored and steered according to the monitoring results.

This calls for the installation of facilities for continuous measurements of the quantity (belt scales) and of thquality of the lignite as a basis for the steering of the selective mining.

The results of these measurements together with the results of special masscalculations aiming to determine the quality of the undiluted lignite can at the same time be used for the determination of the quality andquantity of the diluting intercalations, which are unjknown up to now.

From our point of view this is a follow up activity to be carried out by DAO for all PPC mines.

6.2 Follow up Activities of the Internal Units (Planning Units in the Mines)

The mine planning facilities for the follow up activities described below are not available at present.

As proposed in the phase 2 of the Thalis Symphonia project, the implementation of internal mine planning units is an urgent matter. As we see it, it is not possible, to operate PPC s mines on a high level of equipment utilisation without these internal planning units. Additionally it is our opinion, that the guidelines of the TMMP will remain uneffective, until these internal mine planning units start to execute the TMMP in co-operation with DAO.

Nevertheless PPC appears not to have really adopted the methodology of mine planning described above.

In order to emphasise the necessity to do so again, some of the essential objectives for the mid- and short-term mine planning activities of the internal mine planning units in context with findings of the work of the Masterplan Team are presented below.

Apart from these mid and short term planning activities

There are follow up activities, which are to be carried out generally in every mine regularly. Additionally there are special problems in almost each of PPC s mines in the LCPa and in the LCM, which call for mid- and short-term planning actions. The objective of these follow up measures is

- to improve the performance of the mine equipment (Cost reductions) and
- to increase the safety of the supply of lignite to the consumers (Quantity and Quality).

6.2.1 General Problems

General problems, which cannot be dealt with in an aprropriate way at present are for instance the regular check up of the drive power requirements and the adjustment of the yearly mine planning to the seasonal changes of the lignite demand.

Drive power requirements:

The lack of drive power is an important operational constraint at present. This is one of the reasons why the load factor achieved up to now has remained below an acceptable level.

The drive power reqirements depend among others of the length and the lift of the individual conveyor sections. The lift of the conveyor sections cannot be determined once for ever, because the elevation of the benches is the most important tool for the regulation of the mine progress. Without adjusting the bench elevations regularly, the unhampered operation of the excavators and spreaders in a mine, the achievement of the yearly and monthly production targets cannot be ensured.

In order to keep the belt conveyor system equipped with sufficient drive power, the following standard procedure is normally applied:

- The bench elevations are adjusted yearly for the next five (in special cases up to ten years) until the accumulated quantities on the excavation and dump benches fesult in the yearly lproduction targets and until the quantities on each bench correspond to the capacity of the machine on each bench.
- The drive power requirements are calculated subsequently.

At the same time the unhampered progress of each machine is ensured by this procedure and the demad of belt conveyor material for the next years is reviewed. Additionally a mid term schedule of operational events is developed as the basis for the co-ordination of these events with maintenance measures and for the planning of both activities.

It recommended to introduce the above described activities as a standard working procedure.

Seasonal Changes of the Lignite Demand:

In attachment [ATT 37] the seasonal changes of the generation of electricity have been analysed. We observed two peak load periods. From November to February and during July and August the generation of electriciy is higher than the yearly average. The winter peak is higher than the summer peak. Between the peak periods the net generation is below the average generation.

As soon as the general level of the utilisation of the base load capacity increases, these seasonal changes will become smaller. Nevertheless it is necessary to adjust the yearly mine planning to the changing lignite demand, which is the consequence of these changes.

The the capacity of the mines, to release lignite must be higher during the peak periods and lower during the valley periods. without these adjustments the stockpiles cannot fulfill their blending function appropriately.

In PPC s multi layer deposits it is not possible to create reserves of exposed lignite as a preparatory measure for the peak periods. Lignite and intercalations are to be excavated at the ratio found on each bench together.

The lignite release capacity can only be adjusted by adjustments of the eqipment capacity contributing to the lignite release.

The there are various measures to be applied in order to achieve a lignite release capacity, which varies according to the electricity generation of the Power stations:

- During peak periods the lignite releasing excavators operate with higher priority than the overburden excavators.
- It can be tried to keep operational events (belt shifting. extension of belt sections, transportation of excavators etc.) out of the peak periods.
- By adjustments of the bench elevations the ratio on the uppermost lignite releasing bench can be increased during valley periods and reduced during peak periods. This is a very effective adjustment of the excavator capacity contributing to the relese of lignite.

The actual variation of the lignite release requirements can only be assessed for a short period of time (Say one year). In this context the schedule of revisions of the power station units is important. It will never remain as set at the beginning of a year. The mine planning is to be adjusted according to these changes of the schedule of operation for the power station.

It is obvious, that this kind of activities require more mine planning capacity than available at present. The negative effects which are to be accepted, if these activities cannot be executed are obvious too.

6.2.2 LCPA

Until 2020 the LCPA will be subject to considerable changes. A complex time schedule is to be designed and steered. According to our experience this possibility can only be achieved by the regular review of a detailed bench wise mid- and short term mine planning.

The special events on the time schedules of PPC s mines will be mentioned below.

6.2.2.1 LCPA - North Field

The North Field is one of the two lignite suoppliers for the Liptol and Ptolemais Power stations according to our concept of development. Its equipment is to be transferred to the West Field North within a mid term period of time after the exhaustion of ist reserves. The same applies to the Komanos mine.

In order to expand the period of time for this activity the exploitation of the North Field is to be expedited. At the same time the increased lignite release by the North Field allows to reduce the mining ratio in the Komanos mine, which is to release the major fraction of the Liptol and Ptolemais lignite demand during the development of the West Field North. This applies especially to the expit dump N° 2, where at the same time overheights can be removed by a contractor.

The transition of the North Field equipment requires for a time schedule. It is suggested to develop a benchwise mid term planning until the completion of the North Field. In order to allow for the activities in the Komanos mine mentioned above, the highest achievable level of utilisation is to be applied. Prior to the start up of the operation of the North Field equipment in the West Field North it is suggested to overhaul the equipment. An appropriate period of time for this overhaul (according to the results of a checkup by PPC s mechanical and electrical engineers) is to be taken into account for the schedule of development of the West Field North.

6.2.2.2 LCPA - Komanos

According to the concept of development for the North Field described above, the Komanos mine is to remove as much overburden as possible especially in the area of the expit dump N°2 (Contractor) until the North Field reserves are exhausted.

Under this precondition the Komanos mine will be in the position, to release sufficient lignite after the exhaustion of the north Field reserves until the Westfield North development has been completed, the first sectors of the west Field North, which have a high mining ratio, have been exploited and the capacity of the Liptol and Ptolemais Power stations has been reduced. Only one Ptolemais unit will be still operating,when at the end of this period of time the Komanos reserves will be exhausted.

The steering of the Komanos mines according to the changing objectives described above requires a benchwise mid term planning for a five years period, which is to be reviewed yearly. close to the exhaustion of the Komanos reserves, the schedule for the transition of the Komanos equipment to the West field North is another objective of this planning.

6.2.2.3 LCPA - West Field North

The detailed bench wise planning of the West Field north is an urgent matter. When the work of the Masterplan Team commenced the first lignite from the West Field North was scheduled for 1997. Our present schedule calls for the first lignite from the West Field North for the year 2000, one year before the Komanos reserves will be exhausted. The preceding mine development is to begin in 1998.

In context with the development of the West Field North, the design of the energy supply for this new mine by PPC s electrical engineers has been initiated. This development is scheduled to begin with the employment of an excavator plus spreader and belt conveyor material from the Amyntaion mine. PPC s engineers regard it impossible, to prepare the energy supply for the West Field North by 1998.

A decision about the Amyntaion eqipment is still pending. Nevertholess it is necessary, to initiate the planning of this transportation of the aforementioned equipment just now.

It is too late for the specification and the procurement of new equipment and this solution is not regarded economical.

As we see it the capacity of the Amyntaion equipment cannot be substituted by a contractor without problems. It is not easy, to load and transport about 23 [Mm³/a] crossing a public road.

There is, however, an option, to postpone the start up of the development of the West Field North and possibly the employment of amyntaion equipment in the West Field North as well by the supply of dry lignite to the Ptolemais power station. This requires, however, the following sequence of actions:

- General decision about the supply of dry lignite to the Ptolemais power station base on an investigation of the economical feasibility (We suggest to use support by RE. There was a contract about the supply of dry lignite to the Kardia Power station in the Past, which has not been executed for unknown reasons. RE is familiar with the problem).
- Design and installation of transportation facilities from the Ptolemais briquetting plant to the Ptolemais power station.
- Design and installation of facilities for the blending of dry lignite with teh mine production supplied to the Ptolemais power station (Lignite sampling and analysis, See section 4 of this report)
- Rewiew of the masscalculations and the subsequent long term mine planning for the the North Field, Komanos and the West Field North.
- Preparation of the aforementioned mid term plans for the North Field, Komanos and the West Field North.

This seqence of actions includes long-term planning activities (External unit) and mid-term planning activities by the internal unit.

6.2.2.4 LCPA - Sector 6 & West Field South

In the Sector 6 & West Field South mine a multiltude of co-ordination requirements is to be dealt with.

During the exploitation of the Sector 6 a relocation of the belt distribution point is to be carried out.

The relocated distribution point of the sector 6 will be used for the exploitation ofthe West Field South after the exhaustion of the sector 6 reserves. This opportunity is achieved by the relocation of th Soulöou creek. The alignment for this relocation is to be prepared in time by an co ordinated operation of the internal dumps of theSector 6 and the South Field

The relocation of the belt distribution point of the Sector 6 calls for an extended bench wise mid term planning (Ten instead of five years) as soon as possible

Aside of the Ptolemais and Liptol power stations the Kardia power station is another consumer of PPC lignite, where a calorific value above 1 300 [kcal / kg] has been specified. The supplier of lignite is the Sector 6 & West Field South. Additionally the lignite in the safety pillar of the Ptolemais and Liptol power stations is to be delivered to the Kardia power station, whereas the lignite in the safety pillar of the Kardia power station will be dlivered to the Agios Dimitrios power station, where the specified calorific value is lower.

1 200 < Lower Calorific Value [kcal / kg] < 1710.

The evaluation of the safety pillar of the Kardia power station according to the calorific value specified for the Agios Fimitrios power station instead of the Kardia power station resulted in considerably increasing reserves and a decreasing ratio.

Accordingly the option, to dry a fraction of the lignite supply for the Kardia power station, in order to achieve the same effects for the whole Sector 6 & West Field South should be investigated from our point of view-

6.2.2.5 LCPA - South Field

In the South Field the progress of the intermal dump needs to be reviewed and adjusted. in principle it has been introduced to early. Additionally the the relocation of the belt distribution point is to be steered based on an extended mid term planning (Ten instead of five years).

6.2.2.6 LCPA - Amyntaion

The special problems in the Amyntaion mine, which need the steering by a mid term planning are the increasing depth of the mine and the early introduction of the internal dump.

According to the masscalculation by the Masterplan Team the mine bottom is generally deeper than assumed up to now. An appropriate adjustment of the mid-term mine planning is urgent. A part of the lignite deposit could be left unexploited by the last bench, for the more expensive exploitation by conventional equipment.

In the Amyntaion mine the critical mine position is reached extremely late. Due to Geomechanical considerations the early start up of internal dumping is, however necessary. In this situation the progress of the internal dump needs regulation by the regular review of the mid term duing plans.

6.2.3 LCM

In the LCM the situation is not as complicated as in the LCPA.

Mid-term planning requirements are related to the status of development of the Horemi mine.

In the Goergen Study the necessity to blend the different lignite qualities in the northern of in the southern part of the deposit have been emphasised. As we see it, this does not apply. Corresponding to the decreasing power station capacity the lignite production should be concentrated on the Horemi mine.

6.2.3.1 LCM - Horemi

In the Horemi mine the volume of the expit dump is almost consumed at present. At the same time the development of three excavation benches and three benches of the inpit dump is still pending. This development is to be completed prior to the complete consumption of the expit volume.

The achievement of this target can be achieved by operating the existing three excavation benches with an increased excavation height at low priority. The misiing three benches are to be developed and then operated with the highest possible priority. The same applies to the benches of the inpit dump.

The execution of this concept calls for an extended bench wise mid-term planning for the Horemi mine.

6.2.3.2 LCM - Marathousa

In the Marathousa mine our long time concept is already based on a rough bench wise masscalculation, because a mine depth for four excavators is excavated by two excavators only. After all benches in the Horemi mine have been installed the Marathousa mine is to proceed wit high priority. In order to support the perimeter slope of Marathousa with an inpit dump and to increase the insufficient dump volume for ash in the former Thoknia mine, the final void of the Marathousa mine will be completely filled up with ash and Horemi waste.

The necessity to schedule and steer these activities by a regularly reviewed mid term planning need no further clarification.

6.2.3.3 LCM - Kyparissia

After having achieved the targets described above for Horemi and Marathousa, The exploitation of the remaining Kyparissia reserves is to be expedited (Co-ordination of the mid-term planning in Horemi and Kyparissia).

7 References

In this last section of the report references, which are quoted in the reporthave been collected

This includes:

- Deposit relevant documents, which have been the basis for the determination of the future drilling requirements.
- a list of large format drawings, which have been prepared during the work of the Masterplan Team,
- documents, referring to technical matters we have dealt with in context with the Technical Mine Master Plan,
- Clarifications and definitions referring to this report.

7.1 Deposit-Relevant Documents

These are documents, which have been used as the base for the determination of the future drilling requirements.

7.1.1 Lignite Centre Ptolemais Amyntaion (LCPA)

- General topographical map, scale: 1:50,000, total mining area,
- topographical map, scale: 1:10,000, Ptolemais area, situation: mid 1994,
- topographical map, scale: 1:10,000, Amyndeon area, situation: June 1993,
- eight topographical maps, scale: 1:5,000, Ptolemais area, situation: June 1994

7.1.1.1 Area: Ptolemais, South Field

- Tectonic map, scale: 1:10 000,
- map showing the waste thicknesses (& tectonics), scale: 1:10 000, *
- general drilling map, scale: 1:10 000 ;
- 23 geological sections only northern part of the field, longitudinal scale: 1:2,500, altitudinal scale: 1:2 500 ** ,
- sections (only drill holes: 20), longitudinal scale: 1:10,000, altitudinal scale: 1:1,000 * ,
- List with depth data of the Neritina and Sand X.A. key horizons * ,

7.1.1.2 Area: Sector 6 and West Field, Southern Part

- Deposit maps (incl. tectonics:17), scale: 1:10,000, *
- General drilling map, scale: 1:10,000 ,
- 36 geological sections, longitudinal scale: 1:5,000, altitudinal scale: 1:5,000 ** ,
- 13 sections (only drill holes), longitudinal scale: 1:10,000, altitudinal scale: 1:1,000 * ,
- List with depth data of the Neritina and Sand X.A. key horizons * ,

7.1.1.3 Area: Northern Part, West Field

- 17 deposit maps (see West Field, southern part), *
- general drilling map, scale: 1:10,000 ,
- 36 geological sections (see West Field, southern part) * ,
- 14 sections (only drill holes), longitudinal scale: 1:10,000, altitudinal scale: 1:2,000 * ,
- List with depth data of the Neritina and Sand X.A. key horizons * .

7.1.1.4 Proastio Area

- General drilling map, scale: 1:10 000[*],
- 9 sections (only drill holes), longitudinal scale: 1:10 000, altitudinal scale: 1:2 000,
- List with depth data of the Neritina and Sand X.A. key horizons[*].

7.1.1.5 North Field Area

- General drilling map, scale: 1:10 000[*],
- 6 sections (only drill holes), longitudinal scale: 1:10 000, altitudinal scale: 1:1 000[*],
- list with depth data of the Neritina and Sand X.A. key horizons[*].

7.1.1.6 Agios Christopheros Area (East Field)

- Tectonic map, scale: 1:10 000
- 12 geological sections, longitudinal scale: 1:5 000, altitudinal scale: 1:5 000[**],
- List with depth data of the Neritina and Sand X.A. key horizons[*].

7.1.1.7 Amyntaion Area

- Tectonic map, scale: 1:10 000
- General drilling map, scale: 1:10 000[*].
- 25 geological sections, longitudinal scale: 1:5 000, altitudinal scale: 1:5 000[**],
- 23 sections (only drill holes), longitudinal scale: 1:10,000, altitudinal scale: 1:1,000
- List with depth data of the Neritina and Sand X.A. key horizons[*].

7.1.1.8 Lakkia Area

- Tectonic map, scale: 1:10 000,
- 15 geological sections, longitudinal scale: 1:5 000, altitudinal scale: 1:5 000[**].

7.1.2 Lignite Centre Megalopolis (LCM)

- Topographical map, scale: 1:10 000, total mining ,
- 11 opencast mine maps, scale: 1:2 000,
- Section of the total mining area; longitudinal scale: 1:10 000, altitudinal scale: 1:1 000.

7.1.2.1 Khoremi/Marathoussa Area

- General drilling map, scale: 1:10 000 *,
- Map of the overburden / lignite ratio, scale: 1:10 000 *,
- 18 geological sections, only representation of lignite, longitudinal scale: 1:2 000, altitudinal scale: 1:1 000 **,
- 17 sections (only drill holes), longitudinal scale: 1:10 000, altitudinal scale: 1:1 000 *,

7.1.2.2 Kyparissia Area

- General drilling map, scale: 1:10 000 *,
- Map of the overburden / lignite ratio, scale: 1:5 000 *,
- 8 sections (only drill holes), longitudinal scale: 1:10 000, altitudinal scale: 1:1 000 *.

* :The documents were prepared by the Technical Mine Master Plan Team, Athens.

The following is to be mentioned in respect of the mostly 10-fold increased sections that are provided by the Master Plan and marked with *,:

The sections represent only those layers in the drill holes that are classified as lignite. No data on the type and thicknesses of the associated waste layers (overburden, intercalations, floor) are available.

The position of the cross sections differ from the drill hole grid prevailing in the Ptolemais basin resulting in drillholes being often located far away from the cross sections, which involves that some of them are only difficult to interpret.

** : Major part of the geological sections are of a former date. Th , are widely based only on part of the holes drilled so far.

7.2 Large Format Drawings - Code

Lign. Center-Field-Mine	Code	-	Mine Part	Code	/	Variant Code	/	N°
LCPA	LCPA	-	Others	0	/	1-n	/	1-n
LCPA-Amyntaion	A	-			/	1-n	/	1-n
LCPA-Main Field-North Field	B	-	Excavation	1	/	1-n	/	1-n
LCPA-Main Field-Komanos	C	-			/	1-n	/	1-n
LCPA-Kardia-Kardia	D	-	Dump	5	/	1-n	/	1-n
LCPA-Kardia-Sector 6	E	-			/	1-n	/	1-n
LCPA-Kardia-AOK	F	-			/	1-n	/	1-n
LCPA-South Field	G	-			/	1-n	/	1-n
LCPA-West Field-North	L	-			/	1-n	/	1-n
LCPA-West Field-South	M	-			/	1-n	/	1-n
LCPA-East Field	N	-			/	1-n	/	1-n
LCM	LCM	-				1-n		1-n
LCM-Horemi	H	-			/	1-n	/	1-n
LCM-Marathousa	J	-			/	1-n	/	1-n
LCM-Thoknia	K	-			/	1-n	/	1-n

7.2.1 Large Format Drawings - LCPA

N°	Code	Date	Title	Scale
1	LCPA- 0 / 01	20.10.94	Plan of site LCP	1 : 25000
2	LCPA- 0 / 02	20.10.94	Railway relocation Alternatives A & B	1 : 10000
3	LCPA- 1 / 03	26.10.94	Mine limits as defined by TMMP map by PPC	1 : 25000
4	LCPA- 1 / 04	26.10.94	Mine limits as defined by TMMP for Amyntheon	1 : 25000
5	LCPA- 0 / 05	20.07.94	Bunker and haulage layout Amyntheon	1 : 2000
6	LCPA- 0 / 06	20.07.94	Bunker and haulage layout Agios Dimitrios	1 : 2000
7	LCPA- 0 / 07	21.07.94	Bunker and haulage layout Power Plant Ptolemais	1 : 2000
8	LCPA- 5 / 08	07.07.94	Isolines of the dumps Ptolemais done by Comp. (Intergraph)	1 : 10000
9	LCPA- 5 / 09	07.07.94	Isolines of the dumps Amyntheon done by Comp. (Intergraph)	1 : 10000
10	LCPA- 0 / 10	01.06.94	Mine position 6/1993 Ptolemais	1 : 25000
11	LCPA- 0 / 11	01.06.94	Mine position ca. 1998 Ptolemais 1. idea	1 : 25000
12	LCPA- 0 / 12	01.06.94	Mine position ca. 2010 Ptolemais 1. idea	1 : 25000
13	LCPA- 0 / 13	01.06.94	Mine position ca. 2020 Ptolemais 1. idea Alternative 1	1 : 25000
14	LCPA- 0 / 14	01.06.94	Mine position ca. 2020 Ptolemais 1. idea Alternative 2	1 : 25000
15	LCPA- 0 / 15	01.06.94	Suggestion to exploit Komanos, North-West (North)F.1.idea	1 : 25000
16	LCPA- 0 / 16	01.06.94	Mine position ca. 2020 Amyntheon 1. idea	1 : 25000
17	LCPA- 0 / 17	22.02.95	Concept of reclamation (P 1)	1 : 10000
18	LCPA- 0 / 18	22.02.95	Concept of reclamation (P 2)	1 : 10000
19	LCPA- 0 / 19	23.03.95	Concept of reclamation (A 1)	1 : 10000
20	LCPA- 0 / 20	22.02.95	Concept of reclamation (A 2)	1 : 10000
21	LCPA- 0 / 21	22.02.95	Concept of reclamation (P)	1 : 50000
22	LCPA- 0 / 22	22.02.95	Concept of reclamation (A)	1 : 50000
23	LCPA- 0 / 23	01.03.95	Reserves of Sector 6 and West F. if South F. V. 7 applies	1 : 50000
24	LCPA- 0 / 24	10.11.94	Bunker and haulage layout Power Plant Kardia	1 : 2000
25	LCPA- 0 / 25	09.06.95	Suggestion to reclaim the Main Field Area (End of 2001)	1 : 10000
26	LCPA- 0 / 26	30.03.95	Land reclamation (Main Field Area)	1 : 10000
27	LCPA- 0 / 27	10.06.95	Suggestion to reclaim the Main Field Area (End of 2008)	1 : 10000
28	LCPA- 0 / 28	01.05.95	Proposal of reclamation in the LCP - A	1 : 25000
29	LCPA- 0 / 29	01.05.95	Proposal of reclamation in the LCP - A	1 : 25000
30	LCPA- 0 / 30	01.05.95	Proposal of reclamation in the LCP - A Details A/B/C	1 : 1000
31	LCPA- 0 / 31	20.12.95	Mine Positions Ptolemais 1995	1 : 25 000
32	LCPA- 0 / 32	10.01.96	Mine Positions Ptolemais 2000	1 : 25 000
33	LCPA- 0 / 33	10.01.96	Mine Positions Ptolemais 2010	1 : 25 000
34	LCPA- 0 / 34	10.01.96	Mine Positions Ptolemais 2020	1 : 25 000
35	LCPA- 0 / 35	20.12.95	Mine position Amyntaion 1995	1 : 10 000
36	LCPA- 0 / 36	10.01.96	Mine position Amyntaion 2000	1 : 10 000
37	LCPA- 0 / 37	10.01.96	Mine position Amyntaion 2010	1 : 10 000
38	LCPA- 0 / 38	10.01.96	Mine position Amyntaion 2020	1 : 10 000

7.2.1.1 Large Format Drawings - LCPA - North Field

N°	Code *)	Date	Title	Scale
1	B- 1 / 0 / 01	05.08.94	Open pit boundary	1 : 10000
2	B- 1 / 1 / 02	19.09.94	Sectors of excavation side	1 : 10000
3	B- 5 / 1 / 03	22.09.94	Sectors of dumping side	1 : 10000
4	B- 5 / 0 / 04	22.09.94	Suggestion for a surface to reclaim the inside dump	1 : 10000
5	B- 0 / 0 / 05	26.10.94	Technical top	1 : 10000
6	B- 0 / 0 / 06	26.10.94	Economical bottom	1 : 10000
7	B- 0 / 0 / 07	26.10.94	Exploitation ratio (A : K m^3/ t)	1 : 10000
8	B- 0 / 0 / 08	26.10.94	Map of drilling site with line of intersection	1 : 10000
9	B- 0 / 0 / 09	26.10.94	Geological cross-section 1 - 6 with tech. top + eco. bottom	1 : 10000
10	B- 0 / 0 / 10	30.03.95	Land reclaimed with masses from North Field Mine	1 : 10000
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7.2.1.2 Large Format Drawings - LCPA - Komanos, AOK, Eastfield

N°	Code *)	Date	Title	Scale
1	C- 1 / 0 / 01	05.08.94	Open pit boundaries Komanos & Sci. Exc., AOK, Agios Christophoros	1 : 10000
2	C- 0 / 0 / 02	27.10.94	Technical top	1 : 10000
3	C- 0 / 0 / 03	27.10.94	Technical bottom	1 : 10000
4	C- 0 / 0 / 04	27.10.94	Exploitation ratio (A : K m^3/ t)	1 : 10000
5				
6	C- 5 / 0 / 06	02.03.95	Sectors of dumping side	1 : 10000
7	C- 0 / 0 / 07	30.03.95	Land demand for the excavations	1 : 10000
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7.2.1.3 Large Format Drawings - LCPA - Sector 6 & West Field South

N°	Code	Date	Title	Scale
1	EM- 1/ 0 / 01	16.08.94	Open pit boundaries Sector 6 and West Field	1 : 10000
2	EM- 0/ 0 / 02	20.10.94	Technical top	1 : 10000
3	EM- 0/ 0 / 03	20.10.94	Economical bottom	1 : 10000
4	EM- 0/ 0 / 04	20.10.94	Exploitation ratio (A : K m^3/ t)	1 : 10000
5	EM- 0/ 0 / 05	01.10.94	Map of drilling site with lines of intersection	1 : 10000
6	EM- 0/ 0 / 06	01.10.94	Geological cross - section with tech. top and econ. bottom	1 : 10000
7	EM- 1/ 0 / 07	14.11.94	Open pit boundaries including Sektor "K"	1 : 10000
8	EM- 1/ 1 / 08	17.11.94	Sectors of excavation side Variant 1	1 : 10000
9	EM- 5/ 0 / 09	18.11.94	Surface for a recultivation (Suggestion)	1 : 10000
10	EM- 5/ 1 / 10	21.11.94	Sectors of dumping side Variant 1	1 : 10000
11	EM- 1/ 2 / 11	13.12.94	Sectors of excavation side Variant 2	1 : 10000
12	EM- 5/ 2 / 12	21.12.94	Sectors of dumping side Variant 2	1 : 10000
13	EM- 1/ 0 / 13	15.02.95	Open pit boundaries Sector 6 and West Field Mine	1 : 10000
14	EM- 1/ 0 / 14	21.02.95	Open pit boundaries Sector 6 and West Field Mine	1 : 10000
15	EM- 1/ 0 / 15	25.02.95	Safety distance from the Power Plant Kardia	1 : 10000
16	EM- 1/ 3 / 16	28.02.95	Sectors of excavation side Variant 3	1 : 10000
17	EM- 5/ 3 / 17	01.03.95	Sectors of dumping side Variant 3	1 : 10000
18	EM- 1/ 0 / 18	17.02.95	Map of drilling site with suggested boreholes	1 : 10000
19	EM- 1/ 0 / 19	25.05.95	Level of the 1st Bench	1 : 10000
20	EM- 1/ 0 / 20	25.05.95	Level of the 2nd Bench	1 : 10000
21	EM- 1/ 0 / 21	25.05.95	Level of the 3rd Bench	1 : 10000
22	EM- 1/ 0 / 22	25.05.95	Level of the 4 th Bench	1 : 10000
23	EM- 1/ 0 / 23	25.05.95	Level of the 5 th Bench	1 : 10000
24	EM- 1/ 0 / 24	25.05.95	Level of the 6 th Bench	1 : 10000
25	EM- 1/ 0 / 25	25.05.95	Level of the 7 th Bench	1 : 10000
26	EM- 1/ 0 / 26	25.05.95	Level of the 8 th Bench	1 : 10000
27	EM- 1/ 0 / 27	25.05.95	Position of the mine end of 2017	1 : 10000
28	EM- 1/ 0 / 28	25.05.95	Position of the mine end of 2019	1 : 10000
29	EM- 1/ 0 / 29	25.05.95	Position of the mine end of 2021	1 : 10000
30	EM- 1/ 0 / 30	25.05.95	Position of the mine end of 2023	1 : 10000
31	EM- 1/ 0 / 31	25.05.95	Position of the mine end of 2025	1 : 10000
32	EM- 1/ 0 / 32	25.05.95	Position of the mine end of 2030	1 : 10000
33	EM- 1/ 0 / 33	25.05.95	Position of the mine end of 2035	1 : 10000
34	EM- 1/ 0 / 34	25.05.95	Position of the mine end of 2040	1 : 10000
35	EM- 0/ 0 / 35	30.03.95	Land demand (Sector 6)	1 : 10000
36	EM- 1/ 0 / 36	26.06.95	Relocation of DP, Phase 1 (End of 2009)	1 : 10000
37	EM- 1/ 0 / 37	26.06.95	Relocation of DP, Phase 2 (Begin of 2010)	1 : 10000
38	EM- 1/ 0 / 38	26.06.95	Relocation of DP, Phase 3 (Middle of 2011)	1 : 10000
39	EM- 1/ 0 / 39	30.03.95	Land reclaimed from the inside dump	1 : 10000
40	EM- 1/ 0 / 40	30.01.96	Level of the first bench	1 : 5 000
41	EM- 1/ 0 / 41	30.01.96	Level of the second bench	1 : 5 000

N°	Code	Date	Title	Scale
42	EM- 1/ 0 / 42	30.01.96	Level of the third bench	1 : 5 000
43	EM- 1/ 0 / 43	30.01.96	Level of the fourth bench	1 : 5 000
44	EM- 1/ 0 / 44	05.02.96	Level of the fifth bench	1 : 5 000
45	EM- 1/ 0 / 45	06.02.96	Level of the sixth bench	1 : 5 000
46	EM- 1/ 0 / 46	06.02.96	Level of the seventh bench	1 : 5 000
47	EM- 1/ 0 / 47	07.02.96	Level of the eightth bench	1 : 5 000

7.2.1.4 Large Format Drawings - LCPA - South Field

Nº	Code *)	Date	Title	Scale
1	G- 1 / 0 / 01	10.08.94	Open pit boundary South Field without Sarigiol Field	1:10000
2	G- 1 / 3 / 02	29.09.94	Sectors of excavation side Variant 3	1:10000
3	G- 1 / 2 / 03	10.10.91	Sectors of excavation side Variant 2	1:10000
4	G- 1 / 1 / 04	12.10.94	Sectors of excavation side Variant 1	1:10000
5	G- 1 / 4 / 05	14.10.94	Sectors of excavation side Variant 4	1:10000
6	G- 0 / 0 / 06	14.10.94	Technical top	1:10000
7	G- 0 / 0 / 07	14.10.94	Economical bottom	1:10000
8	G- 0 / 0 / 08	14.10.94	Exploitation ratio (A : K) m³ / t	1:10000
9	G- 5 / 4 / 09	18.10.94	Sectors of dumping side Variant 4	1:10000
10	G- 5 / 2 / 10	18.10.94	Sectors of dumping side Variant 2	1:10000
11	G- 5 / 3 / 11	19.10.94	Sectors of dumping side Variant 3	1:10000
12	G- 5 / 1 / 12	20.10.94	Sectors of dumping side Variant 1	1:10000
13	G- 0 / 0 / 13	24.10.94	Border by PPC study from 2.07.1982 Map: MK 3785a	1:10000
14	G- 0 / 0 / 15	02.08.94	Map of drilling site with lines of intersection	1:10000
15	G- 0 / 0 / 14	01.10.94	Geological cross-section 1 - 20 with tech. top + eco. bottom	1:10000
16	G- 1 / 0 / 16	04.11.94	Open pit bound.South with Haravgi separate and Sarigiol F.	1:10000
17	G- 1 / 5 / 17	08.11.94	Sectors of excavation side Variant 5	1:10000
18	G- 5 / 1 / 18	09.11.94	Sectors of dumping side Variant 1 without "K"	1:10000
19	G- 5 / 5 / 19	09.11.94	Sectors of dumping side Variant 5	1:10000
20	G- 5 / 3 / 20	10.11.94	Sectors of dumping side Variant 3 without "K"	1:10000
21	G- 5 / 4 / 21	10.11.94	Sectors of dumping side Variant 4 without "K"	1:10000
22	G- 5 / 2 / 22	10.11.94	Sectors of dumping side Variant 2 without "K"	1:10000
23	G- 1 / 6 / 23	11.11.94	Sectors of excavation side Variant 6	1:10000
24	G- 5 / 0 / 24	21.11.94	Suggestion for a recultivation surface	1:10000
25	G- 5 / 6 / 25	01.12.94	Sectors of dumping side Variant 6	1:10000
26	G- 1 / 7 / 26	25.01.95	Sectors of excavation side Variant 7	1:10000
27	G- 5 / 7 / 27	25.01.95	Sectors of dumping side Variant 7	1:10000
28	G- 1 / 1 / 28	17.01.95	Mine position after completion of the outside dump South F.	1:40000
29	G- 1 / 1 / 29	17.01.95	Mine position after completion of the outside dump Main F.	1:40000
30	G- 1 / 1 / 30	01.02.95	Max. dam (Soulou) dumping by South Field Mine	1:40000
31	G- 1 / 1 / 31	17.01.95	Final position of South Field Mine	1:40000
32	G- 1 / 2 / 32	18.01.95	Mine position after completion of the outside dump South F.	1:40000
33	G- 1 / 2 / 33	18.01.95	Mine position after completion of the outside dump Main F.	1:40000
34	G- 1 / 2 / 34	02.02.95	Max. dam (Soulou) dumping by South Field Mine	1:40000
35	G- 1 / 2 / 35	18.01.95	Final position of South Field Mine Variant 2	1:40000
36	G- 1 / 3 / 36	18.01.95	Mine position after completion of the outside dump South F.	1:40000
37	G- 1 / 3 / 37	18.01.95	Mine position before relocation of the distribution point S. F.	1:40000
38	G- 1 / 3 / 38	19.01.95	Mine position after completion of the outside dump Main F.	1:40000
39	G- 1 / 3 / 39	02.02.95	Max. dam (Soulou) dumping by South Field Mine	1:40000
40	G- 1 / 3 / 40	19.01.95	Final position of South Field Mine Variant 3	1:40000
41	G- 1 / 4 / 41	18.01.95	Mine position after completion of the outside dump South F.	1:40000

N°	Code *)	Date	Title	Scale
42	G- 1 / 4 / 42	18.01.95	Mine position after completion of the outside dump Main F.	1:40000
43	G- 1 / 4 / 43	19.01.95	Mine position before relocation of the distribution point S. F.	1:40000
44	G- 1 / 4 / 44	02.02.95	Max. dam (Soulou) dumping by South Field Mine	1:40000
45	G- 1 / 4 / 45	19.01.95	Final position of South Field Mine Variant 4	1:40000
46	G- 1 / 5 / 46	19.01.95	Mine position after completion of the outside dump South F.	1:40000
47	G- 1 / 5 / 47	19.01.95	Mine position after completion of the outside dump Main F.	1:40000
48	G- 1 / 5 / 48	20.01.95	Mine position before relocation of the distribution point S. F.	1:40000
49	G- 1 / 5 / 49	03.02.95	Max. dam (Soulou) dumping by South Field Mine	1:40000
50	G- 1 / 5 / 50	20.01.95	Final position of South Field Mine Variant 5	1:40000
51	G- 1 / 6 / 51	20.01.95	Mine position before relocation of the distribution point S. F.	1:40000
52	G- 1 / 6 / 52	20.01.95	Mine position after completion of the outside dump Main F.	1:40000
53	G- 1 / 6 / 53	20.01.95	Mine position after completion of the outside dump South F.	1:40000
54	G- 1 / 6 / 54	03.02.95	Max. dam (Soulou) dumping by South Field Mine	1:40000
55	G- 1 / 6 / 55	20.01.95	Final position of South Field Mine Variant 6	1:40000
56	G- 1 / 7 / 56	08.02.95	Mine position after completion of the outside dump South F.	1:40000
57	G- 1 / 7 / 57	08.02.95	Mine position before relocation of the distribution point S. F.	1:40000
58	G- 1 / 7 / 58	08.02.95	Mine position after completion of the outside dump Main F.	1:40000
59	G- 1 / 7 / 59	10.02.95	Mine position after cutting the river Soulou	1:40000
60	G- 1 / 5 / 60	13.02.95	Development of the belt conveyor Variant 5	1:10000
61	G- 1 / 5 / 61	13.02.95	Development of the belt conveyor Variant 6	1:10000
62	G- 1 / 0 / 62	12.04.95	Adjustment of Variant 5 in the Haravgi Area	1:40000
63	G- 0 / 0 / 63	17.02.95	Map of drilling site with suggested boreholes	1:10000
64	G- 0 / 0 / 64	31.03.95	Land reclaimed from the outside dump	1:10000
65	G- 0 / 0 / 65	31.03.95	Land demand for the excavation	1:10000
66	G- 0 / 0 / 66	31.03.95	Land reclaimed from the inside dump	1:10000
67	G- 0 / 0 / 67	31.03.95	Land demand for the outside dump	1:10000
68	G- 1 / 0 / 68	14.06.95	Excavation of Sector "K" from South Field	1:40000
69	G- 1 / 0 / 69	20.06.95	Relocation of DP Phase 1 (2005)	1:10000
70	G- 1 / 0 / 70	20.06.95	Relocation of DP Phase 2 (2008)	1:10000
71	G- 1 / 0 / 71	20.06.95	Relocation of DP Phase 3 (2011)	1:10000

7.2.1.5 Large Format Drawings - LCPA - West Field North

N°	Code	Date	Title	Scale
1	BL- 1/ 0 / 01	08.08.94	Open pit boundary	1 : 10000
2	BL-* / ** / 02			
3	BL- 0/ 0 / 03	27.10.94	Technical top	1 : 10000
4	BL- 0/ 0 / 04	27.10.94	Economical bottom	1 : 10000
5	BL- 0/ 0 / 05	27.10.94	Exploitation ratio (A : K m³/ t)	1 : 10000
6	BL- 0/ 0 / 06	27.10.94	Map of drilling site with lines of intersections	1 : 10000
7	BL- 0/ 0 / 07	27.10.94	Geological cross - section with tech. top + econ. bottom	1 : 10000
8	BL- 1/ 1 / 08	24.11.94	Sectors of excavation side Variant 1	1 : 10000
9	BL- 5/ 1 / 09	20.12.94	Sectors of dumping side Variant 1	1 : 10000
10	BL- 5/ 1 / 10	27.01.95	Surface for recultivation	1 : 10000
11	BL- 1/ 0 / 11	25.02.95	Safety distance from the Power Plant Ptolemais - Liptol	1 : 10000
12	BL- 1/ 2 / 12	01.03.95	Sectors of excavation side Variant 2	1 : 10000
13	BL- 5/ 2 / 13	02.03.95	Sectors of dumping side Variant 2	1 : 10000
14	BL- 1/ 0 / 14	10.04.95	Level of the 1st Bench	1 : 10000
15	BL- 1/ 0 / 15	10.04.95	Level of the 2 nd Bench	1 : 10000
16	BL- 1/ 0 / 16	10.04.95	Level of the 3 rd Bench	1 : 10000
17	BL- 1/ 0 / 17	11.04.95	Level of the 4 th Bench	1 : 10000
18	BL- 1/ 0 / 18	11.04.95	Level of the 5 th Bench	1 : 10000
19	BL- 1/ 0 / 19	11.04.95	Level of the 6 th Bench	1 : 10000
20	BL- 1/ 0 / 20	11.04.95	Level of the 7 th Bench	1 : 10000
21	BL- 1/ 0 / 21	11.04.95	Position of the mine end of 1998	1 : 10000
22	BL- 1/ 0 / 22	11.04.95	Position of the mine end of 2000	1 : 10000
23	BL- 1/ 0 / 23	13.04.95	Position of the mine end of 2002	1 : 10000
24	BL- 1/ 0 / 24	13.04.95	Position of the mine end of 2004	1 : 10000
25	BL- 1/ 0 / 25	13.04.95	Position of the mine end of 2006	1 : 10000
26	BL- 1/ 0 / 26	13.04.95	Position of the mine end of 2011	1 : 10000
27	BL- 1/ 0 / 27	13.04.95	Position of the mine end of 2016	1 : 10000
28	BL- 1/ 0 / 28			
29	BL- 0/ 0 / 29	17.02.95	Map of drilling site with suggested boreholes	1 : 10000
30	BL- 0 / 0/ 30	30.03.95	Land reclaimed from the inside dump	1 : 10000
31	BL- 0 / 0/ 31	30.03.95	Land Demand for the excavation	1 : 10000
32	BL- 0 / 0/ 32	30.03.95	Variant 2	1 : 10000
33	BL- 0 / 0/ 33	14.12.95	Level of first bench	1 : 5 000
34	BL- 0 / 0/ 34	14.12.95	Level of second bench	1 : 5 000
35	BL- 0 / 0/ 35	14.12.95	Level of third bench	1 : 5 000
36	BL- 0 / 0/ 36	14.12.95	Level of fourth bench	1 : 5 000
37	BL- 0 / 0/ 37	14.12.95	Level of fifth bench	1 : 5 000
38	BL- 0 / 0/ 38	14.12.95	Level of sixth bench	1 : 5 000
39	BL- 0 / 0/ 39	14.12.95	Level of seventh bench	1 : 5 000
40	BL- 0 / 0/ 40	14.12.95	Position of the mine 1998	1 : 5 000
41	BL- 0 / 0/ 41	14.12.95	Position of the mine 1999	1 : 5 000
42	BL- 0 / 0/ 42	14.12.95	Position of the mine 2000	1 : 5 000

If the lignite passes a mine stockpile and a power station stockpile prior to consumption in the powerstation the blending procedures, described above, should be applied twice.

We are confident, that this procedures will result in an almost constant lignite quality close to the masscalculation result.

4.1.2 The Buffer Functions of a Stockpile

The second objective of the stockpile management is the safety of supply.The stockpiles serve in this context as a buffer between the mines and the lignite consumers.

In this context the variations of the lignite demand are essential *[ATT 23]*. There is a shorter peak period during the summer (Air conditioning) and a longer peak period during the winter months

The order of magnitude of these variations cannot be overcome with a big stockpile alone. Especially during the winter peak the level of lignite release must be raised by planning measures *[SCT 1.3.2.6]* . even PPC s big lignite stockpiles *[ATT18 15]* will not be sufficient for these variations of the lignite demand in any case.

4.2 Ash Transportation

The methods of ash deposition are related to the environmental aspects of the lignite based electricity generation. correspondingly we have described this matter in *[SCT 4.6.5]*

4.3 The System of Interlinking Lignite Handling Systems

See *[SCT 3.1.7]*

4.4 Earth Removal and Civil Engineering Projects

See *[SCT 3.1.6 & 3.2]*

4.5 Environmental Environmental Study for the LCPA

The environmental impact of lignite mining inclludes the following aspects:

- Reclamation of the mined out areas,
- The influence on groundwater and
- surface water,
- the deposition of the ash in context with the future quality of the groundwater
- dust protection measures

curing the data base. Section *[SCT 1.2.2]* of this report shows what kind of work will become necessary to obtain the required answers.

4.5.5 Ash Deposition and the Future Groundwater Quality

The influence of ash depositions is an area of concern in other lignite centres abroad.

Techniques of depositing ash and other waste products in especially prepared landfills within dumps of waste rocks as required by the authorities in Germany will not be necessary in the Amyntaion - Ptolemais Mining District.

Reasons for this statement are given below:

The lignite fired power plants in the Rhenish Lignite District produce boiler and fly ash, gypsum, and water, containing high concentrations of NaCl.

Gypsum and sodium chloride are waste products of the so-called wet desulfurization process which removes SO_2 from the flue gas. Authorities have set maximum concentrations of sulfate (= noncarbonate hardness), chloride, and other chemical compounds in ground water leaving the dumps, which cannot be met if the waste of powerplants would be dumped along with the waste rock ftom the mines.

These waste products are homogenized on the premises of the power plants, transported by conveyor belts to special clay lined landfills within inpit and expit dumps of some lignite mines and deposited. Homogenization of the mixture ensures that chemical reactions involving the reactive alkaline-earth oxidesof fly ash, gypsum, sodium chloride, and water take place that produce new minerals like ettringite and others.

This mineral growth is accompanied by reduction of porosity in the dumped mass and by an also resulting decline of its hydraulic conductivity. Upon recovery of the ground water table in an inpit dump with such a landfill, the fill will become saturated. But its extremely low hydraulic conductivity ensures that the general flow of ground water in the dump will be around this landfill so that only a very small rate of contaminated water leaving the latter will come in contact with the ground water. Dilution will reduce any excessive concentrations of sulfate or chloride of the fill effluent to acceptable levels.

Here again, PPC is in the fortunate situation of not being required to adopt this or a similar solution even if the power plants should be equipped with desulfurization devices. Contrary to the situation in the Rhineland, the waste materials are mainly impermeable. The rate of solution taking place in the ash - waste rock mix will thus be so low that no harmful effects on the quality of ground water leaving the inpit dumps must be expected.

PPC is thus advised to continue with their present technique of dumping ash from the power plants along with the waste rock from the mines.

4.5.6 Dust Protection Measures

Another environmental aspect is dust suppression. The most important measures in this context are shown in *[ATT 35 - 04]*.

4.5.7 Noise Protection Measures

Whenever an opencast mine approaches a village or city noise protection measures can improve the acceptance of the mine.

There are three options to achieve a reduced noise immission:

- Noise emissions of the mine equipment can be reduced by technical improvements of the equipment itself.
- Inevitable emissions can be reduced by secondary measures as noise protection capsules e. g. for the gear boxles of excavators spreaders and belt conveyors.
- Noise protection walls or earth dams between the mine and a village or can contribute to the reduction of the noise immission.

A more detaied description of measures as such is given in *[SCT 7.3 - 30 - 0]*.

4.6 Personnell - Personnell Training

Detailed proposals for the organisational structure and for the training of PPC s personnell have been submitted by the Thalis Symphonia project including mine planning.

The longterm guidelines of the TMMP must be made effective by mid and short term planning activities which are to be carried out regularly according to these guidelines. The necessary skilled personnel for these planning activities is not available in PPC s mines.

The Implementation of the so called internal planning units in PPC s mines is a precondition for the execution of the TMMP.

	DRS / t	DRS / Gcal
PPC Mines	**2 064**	**1 727** → 1,1951
LCPA Mines	**2 225**	**1 782** → 1,248
Amyntheon	2 573	2 322 → 1,108
Sector 6 & West Field South	2 095	1 615 → 1,2972
West Field North	2 683	2 051 → 1,308
North Field	1 520	1 148 → 1,327
Komanos	3 428	2 791
South Field	1,610	1,282
General LCPA	233	187
LCM Mines	**1 474**	**1 471**
Horemi	1 086	1 095
Marathousa	3 135	3 135
Kyparissia	1 236	1 192
General LCM	175	175

(Not Escalated, duties and taxes, interest, and amortisation are not considered, constant exchange rate) Δεν συμπεριλαμβάνονται φόροι, δασμοί, τόκοι, αποσβέσεις και σταθερή συναλλαγματική σχέση

For details see tables *[ATT ????? -]* 4-1 to 4-5.

Tables*[ATT ????? -]*4-6 to 4-16 list the summarised costs subdivided into cost types for the main cost areas annually and for the total, while table *[ATT ????? -]*4-17 to 4-30 show the annual costs for each mine during the lifetime of this project.

The total expenditure are covering all reasonable expenditure for investments, replacements, labour, parts, contractor services, energy, and consumables as determined in this study. As advised by PPC duties and taxes are not applicable. Δεν συμπεριλαμβάνονται δασμοί και φόροι.

Costs were derived from:

- cost data provided by PPC,
- actual quotations from manufacturers,
- prices known from recently placed orders for similar equipment,
- operating experience from similar equipment world wide.

All cost figures in this analysis are in Greek DRS. They are on price base as of 1995 and were not escalated for the following years.

The exchange rate of

1 DM = 156 DRS

was kept constant over the total time period of the project.

The risk of cost overruns has conservatively been limited by the inclusion of 10 % contingencies for all cost types.

Termination point for the study and thus for the cost estimation is the transfer point at the end of the lignite conveyor, leading to the stockyard of a power plant, but including the transporting and dumping of the ash volumes coming from the power plants.

5.2 Assessment oft he Costs

The cost assessment has been executed as follows.

5.2.1 Subdivision into Major Cost Areas

The total costs have been determined for the major cost areas listed below.

5.2.1.1 Bucketwheel Excavators

All types of bucket-wheel excavators have been summarised in this cost area, although the operating cost have been estimated carefully for each type separately.

5.2.1.2 Spreaders

All types of spreaders used in a mine have been comprised in this cost area.

5.2.1.3 Conveyors

The width of the conveyor lines operated in the different mines ranges from 1000 mm up to 2400 mm.

5.2.1.4 Personnel

This cost area summarises the total expenditure for wages, salaries including employers on cost like taxes and insurances. A subdivision was made into operating and maintenance labour.

5.2.1.5 Other Equipment

This item comprises the costs of :

ground dewatering
surface dewatering
conventional equipment
auxiliary equipment
mine cars and
train transportation.

It was adopted, that the conventional equipment, which is mainly used to remove the hard layers, will be operated by contractors.

5.2.1.6 Other Facilities

Other facilities include the costs for the mine service facilities, the power supply, the control and communication equipment and the workshop equipment.

The operating costs for these facilities represent the cost of maintaining the machinery, equipment, and tools of the workshop, e.g. cranes and forklifts, and the office equipment.

5.2.1.7 Land Acquisition

The cost of one square metre has been assessed to DRS 250. The item land acquisition covers the future demand of land for the mines.

5.2.1.8 Reclamation

The preparation of the final landscape including agricultural and forestrial reclamation has been estimated to 465 DRS per square metre.

5.2.1.9 Resettlements

This area covers the cost for resettlements of houses and other buildings as well as the compensations for their inhabitants.

5.2.1.10 Relocations

The proceeding mines will reach rivers, roads, overhead power lines, and railways in the future. Bucket-wheel excavators, spreaders and conveyors will be transported: material distribution centres and mine service facilities have to be relocated resp. demolished and rebuild again. The costs which will arise by these measures are summarised in the cost area relocations.

5.2.2 Investments and Replacements

According to the scope of work the future investments are to be determined.

5.2.2.1 Determination of Investments,Methodology

Investment and replacement cost were estimated in detail for the following equipment according to the subdivision into cost centres.

- Conveyors 1200 mm
- Conveyors 1400 mm
- Conveyors 1600 mm
- Conveyors 1800 mm
- Conveyors 2400 mm
- Land Acquisition
- Auxiliary Equipment
- Mine Cars.

They represent the additional investments in equipment ready for operation as well as a major replacements during the lifetime of the mines.

They include the costs of transport, erection, and commissioning. A further allowance has been made for initial spare parts and consumables inventory.
Residual values at the end of equipment's economic life or the mine life are disregarded; No costs for the dismantling and removal of equipment were considered because it is supposed, that the salvage values will cover those expenditures.

Moreover the investment cost include additionally an allowance of 10 % for contingencies.

5.2.2.2 Depreciation

The following annually rates of deprecation have been given by PPC :

- Bucket-wheel Excavators 20 %

• Spreaders	20 %
• Belt Conveyors	20 %
• Conventional Mining Equipment	20 %
• Auxiliary Equipment	20 %
• Mine Cars	20 %
• Civil Works	12 %
• Buildings	5 %

The depreciation shown with table *[ATT ????? -]* 4-31 represent only that equipment which will be purchased in the future.
Especially the depreciation of the actual remaining book value of PPC was not considered.

5.2.3 Determination of the Operating Cost

The operating costs are to be calculated as stipulated in the scope of work

5.2.3.1 General Matters in Context with Operating Costs

Operating cost were derived on a year by year basis subdivided into the following cost types:

Labour costs were subdivided into operating labour and maintenance labour. They include all wages, allowances and benefits, and employer's on-cost like taxes and insurance.

Fuel shows the cost of diesel and petrol consumption and power the cost of power consumption.

Material and services cover all supplies, consumables, e.g. oil and grease, spare parts, and outside contractor services.
Additionally an allowance of 5 % has been added for transports of all supplies.

An allowance for operating contingencies has been considered with 10 % on all operating costs.

5.2.3.2 Non-Labour Cost

The non-labour cost contain fuel consumption, power consumption, material and services. Within these items the following price rates were considered :

- Diesel 104 [DRS / litre]
- Electric Energy 10 800 [DRS / MWh]

(all price rates are based on 1995 as advised by PPC)

The non-labour cost were assessed by multiplying

a chosen reference unit for each type of equipment or plant (mostly operating hours)

by an estimated consumption rate times price rate or a cost rate.

The reference units chosen are mostly the corresponding operating hours of the equipment. In the case of belt conveyors a cost rate and a consumption rate per operating hour and kilometre was chosen which reflects the cost to run one kilometre of the belt conveyor for one hour.

This approach allows the actual usage of the equipment and changing lengths of the conveyors to be considered correctly.

For vehicles the reference units are the kilometres driven.

In a few instances, simply a lump sum was fixed to assess the non-labour cost. In this case the lump sums reflect the maximum yearly non-labour cost of the corresponding cost centre. According to the actual utilisation of the equipment, the lump sum was adapted year by year.

The estimated quantities of the reference units are generally derived from the production schedule and machine capacities. The required operating time of support equipment is dependent from the operating hours respectively operating hours times kilometres of the corresponding equipment that they support.

5.2.3.3 Labour Cost

The labour cost were calculated year by year for all types of equipment and facilities. They are subdivided into operating and maintenance labour cost.

In year 2000, a year in which all mines are operating , the total required manpower amounts to:

Manpower in the year 2000

Cost Area	Operation	Maintenance	Total
PPC Mines	**4 594**	**2 351**	**6 945**
LCPA Mines	**3 852**	**1 935**	**5 787**
Amyntheon	493	177	670
Sector 6 & West Field South	647	249	896
West Field North	364	131	495
North Field	273	107	380
Komanos	331	130	461
South Field	1 012	345	1 357
General LCPA	732	796	1 528
LCM Mines	**742**	**416**	**1 158**
Horemi	354	142	496
Marathousa	115	47	162
Kyparissia	119	48	167
General LCM	154	179	333

[ATT ?????? -] 4-32 to 4-34 show the required manpower for operation, maintenance, and the total on a year by year basis for each mine.

The annual manpower was calculated on base of the results of the Thalis Synphonia Project and adapted to future needs.

As advised by PPC the labour cost were established as follows:

Labour Cost per man and hour

Category	Description	[DRS /h]
1	Managers, Engineers	4,110
2	Technology Graduates	3,450
3	Applied Science University Graduates	3,262
4	Skilled Workers, Operators	2,900
5	Semiskilled and Unskilled Workers	2,200

As already mentioned, the above labour cost include all wages, allowances, benefits, and employer's on-cost like taxes and insurance.

more information: Although the waste : lignite ratio of Amyntheon and Sector 6 & West Field (South) are comparably high, their specific cost do not correspond to the ratio.

The utilisation of the main mine equipment (excavators, spreaders and conveyor lines) is another cost influencing factor, which is to be tken into account
A similar situation can be observed referring to Horemi or Marathousa. The specific costs of Marathoussa are very high despite the moderate waste : lignite ratio compared to Horemi. The reason for that is the extremely low utilisation of the main mine equipment, which does not reach half of that in other mines. Kyparissia has also very low utilisation factors, but they are compensated to a certain extent by the very good waste : lignite ratio.

For the South Field we realise a totally different situation : Although the waste : lignite ratio is moderate and the utilisation is low, the specific costs of lignite are comparably low. In that case the economics of scale are responsible for a major part of that result. The lignite production of that mine is more than twice higher than all other mines and the South Field mine operates large sized main mine equipment only.

5.4 Alternative Energy Sources

To compare competitive energy alternatives, it has to be considered, that they also must be qualified to be used in base load power plants like the lignite. This does not apply to natural gas, which is normally used for the production of medium or peak load electric energy.

For the time being the price of imported black coal amounts to

1,800 - 2,000 [DRS / Gcal]

(At a major sea harbour). Considering the transportation costs to existing or possible future power plant sites, this energy price is to be compared to the price of lignite based calorific energy as supplied to the lignite fired power stations. According to the cost calculation in this report this price is:

1 727 [DRS / Gcal].

PPC s lignite is lignite is a competitive source of energy for the production of electric base load energy at present.

Because imported black coal is a strong competitor for the german lignite the future development of the price for this source of energy has been investigated *[SCT 7.3 - 25 - 0]*. This analysis results in a price for imported black coal of

166 [DM / t SKE] -206 [DM / t SKE].

for the year 2010 (At a major german harbour). A ssignificant increase of theprice of imported black coal is expected.

There is a considerable potential for reductions of the cost of PPC lignite as calculated in this study:

5 Cost Estimates And Economic Analysis

The objective of the following section of this report is the cost calculation.

The production costs of each mine and for the total lignite production of PPC during the perios of time until 2020 are to be determined.

5.1 Summary of the Economic Analysis

The economic assessment was carried out according to the following subdivision :

PPC Mines

- **LCPA Mines**
  - Amyntheon
  - Sector 6 & West Field South
  - West Field North
  - North Field
  - Komanos
  - South Field
  - General LCPA
- **LCM Mines**
  - Horemi
  - Marathousa
  - Kyparissia
  - General LCM

All future expenditure were estimated to determine the total expenditure of each mine over the envisaged time period, not including the cost of financing.
The depreciation of new investments and future replacements have additionally been determined.

Over the lifetime of the project the specific cost per tonne of lignite resp. per Gcal (on base of the future expenditure) on price base as of 1995 will accumulate to:

Total Expenditure

According to the level of accuracy of this study an average labour cost rate per man and year was established. Considering the distribution of categories within a mine and the effective working time of

1,840 hrs / year	for mines and
1,805 hrs / year	overall

the uniform rate of

5.928 million DRS per man and year

was used.

5.2.4 Overhead Cost

As advised by PPC a uniform rate of 9.2 % of all operating costs (excluding investments and replacements) has been used to cater for the overhead costs which are not chargeable direct to the mines (offices and expenses in Athens).
This percentage does not include interest and amortisation.

5.2.5 Levelized Unit Cost

To consider the different time periods of expenditure and revenue, the revenue requirement method was used to calculate the levelized unit cost.

Annual costs and lignite volumes are discounted by a certain interest rate;
the accumulated discounted cost amount divided by the accumulated discounted lignite amount results in the levelized unit cost.

Since escalation for costs was not considered, real interest rates have to be used.
The result in DRS / t is that levelized price which would enable an even result for the company over the total time period envisaged.

Or in other words : If the company would get that levelized price for the lignite over the total time period envisaged, the internal rate of return is the chosen interest rate for discounting.

5.3 Comparison of Results

As table *[ATT ????? -]* 4-1 to 4-4 show, there is a strong dependency between the total specific costs per tonne of lignite resp Gcal and the waste : lignite ratio. But the figure gives

- The remaining reserves and the mining ratio have been assessed conservatively due to the lack of accurate deposit information. We expect the follow up activities inthis field to result i increasing reserves and decreasing mining ratios.
- The utilisation of PPCs main mine equipment has been set close to its lower limit.

Additionally a higher utilisation of the lignite fired power stations could contribute to a lower price of the lignite based electric energy.

Taking into consideration the future evolution of the price for black coal and the aforementioned potential of reductions of the price for lignite based electric energy in Greece PPC s lignite centres are expected, to keep their present market position in future.

6 Conclusions & Recommendations

This final section of the report comprises recommendations for the future actualisation of the Technical mine Master Plan and for follow up activities, which are to be carried out, in order to execute the long term concept of development of the TMMP.

The proposed activities can be assigned to the organisational units proposed in the Thalis Symphonia Project. These units are an external unit (Outside of the mine hierarchy) dealing with the long-term concept of development for all PPC mines together (DAO). The future actualisation of the TMMP is to be executed in this organisational unit.

Additional mid- and short-term planning in the so called internal units (Planning units within the hierarchy of the mines) are necessary. The objective of these activities is, to adjust the mid- and short term plans of development for each mine to the long-term concept of development (Inevitable deviations between both concepts are to be removed regularly) and to add the planning details, which cannot be determined in the long-term planning.

Accordingly the following subjects are described:

- Follow up activities of the external unit (DAO),
- Follow up activities of the internal units (Mine planning units in the mines).

The remaining Masterplan Team, which is completing the TMMP at present, is familiar with the problems to be solved. Its project manager was involved in the organisational aspects, which have been dealt with in the phase II of the Thalis Symphonia project and in the preparation of the TMMP. It is suggested to use this group for the execution of the proposals listed below in co-operation With DAO and the internal mine planning units, to be installed in the mines within the ongoing Thalis Symphonia project.

6.1 Follow up Activities of the External Unit (DAO)

There are three essential items of input for the preparation of the longterm concept of development for PPC s lignite mines. These items are:

- The lignite demand,
- the relevant deposit characteristics (Waste and lignite reserves, lignite quality, mining ratio, quality parameters for the strata with out analysis),
- the utilisation of the equipment capacity,
- lignite sampling and analysis

The external unit is to deal with each of these three items in future

6.1.1 The Lignite Demand

The longterm proposal for the lignite demand applied at present is not regarded as the final approach for several reasons.

The present proposal for the long term evolution of the total net generation in the Mainland grid of Greece has been determined by the numerical analysis of the actual generation figures observed in the past. An analysis as such is to be actualised regularly and the erection of additional power station capacity is to be steered accordingly.

The requirements of base load capacity on the one side and of medium- and peak load capacity on the other side are especially important in this context.

As we see it, too much base load capacity has been installed in the past. At present the base load power stations are in the position, to achieve sufficiently high utilisation factors. In the future too much base load capacity is possibly installed again and the utilisation of the base load capacity is reduced correspondingly.

This is likely to apply to the original schedule proposed by PPC s Direction of Programming and Strategic Planning. It does, however, not yet include the decommissioning of units in the LCPA and the LCM, which has been proposed by the Masterplan team according to the remaining lignite reserves in PPC s deposits.

The remaining reserves have not yet been determined finally. The status of the geological interpretation (See 6.1.2) is the reason for some inaccuracy to be removed in future. A considerable potential, to increase the reserves, is the application of „other fuels" with a higher calorific value in addition to PPC lignite (See 6.1.2).

It might be necessary, to replace a fraction of the base load capacity in PPC program for the expansion of the power station capacity by medium and peak load capacity.

The investigations described above, which are to be carried out by DAO in co-operation with PPC s Direction of Programming and Strategic Planning and with the Division of Production are expected to result in a changed lignite production schedule for the mines.
As a consequence of these changes a review of the longterm concept of development for PPC s mines will be necessary in certain distances of time.

6.1.2 The Relevant Deposit Characteristics

The remaining reserves, the lignite quality and the mining ratio have not been determined finally in the Technical Mine Master Plan.

A certain inaccuracy of these figures is to be accepted for long term activities in any case. A deposit is normally completely explored after it has been exploited. In the LCPA and in the LCM this accuracy of the deposit information is, however, not sufficient at present.

Major influences on reserves and ratio are expected by the missing correlation of the strata in the deposits. This influence is related to an improved geometrical representation of the mineable lignite seams. Additionally the quality parameters of the so called layers without analysis, which had to be set in a very conservative way at present, can be substituted by the quality figures of the corresponding layers in other neighbouring drillholes.

As a consequence of the results of geotechnical investigations, which are pending at present.

increasing reserves will possibly be related to the review of the safety pillars around the Kardia- or Ptolemais- and Liptol power stations. These saflety pillars have been set very conservatively. The present status of the geotechnical investigations forced us to do so.

The investigation of the perimeter slopes in the mines might result in reductions of the reserves in some cases. This applies especially to the western perimeter of the two parts of the West Field. These slopes are located at the perimeter of the Ptolemais deposit. In this area strata dipping down towards the mine and faults dipping down in the same direction are to be expected. At the same time a public road and a railway line atop the slope are to be protected.

The necessary geotechnical analysis calls for the co-ordinated action geologists, hydrologists, geotechnicians and mine planners. The co-ordination of the activites schould be assigned to DAO from our point of view.

A considerable influence on the remaining reserves and on the mining ratio can be expected by the application of „other fuels" with a higher calorific value compared to the PPC lignite.

The mixture of both fuels must correspond to the consumers specification. Blending the lignite with another fuel, which is characterized by a higher calorific value allows for a reduction of the calorific value of the lignite. If, however, a lower calorific value of the mine production is acceptable, exploitable reserves of thermal energy will increase and the mining ratio will decrease according to our experience achieved up to now during the preparation of the Technical Mine Master Plan and in other projects. This applies especially to mine fields, which are located close to the perimeter of the total deposit, where thinner lignite layers and thicker intercalations are to be expected (Both parts of the West Field).

We learnt, that PPC regards the application of imported fuels as less favourable in this context. There is, however, a possibility to achieve the effects described above without the application of imported fuels.

In the case of the Liptol and Ptolemais power stations a lower calorific value of the mine production can be accepted, if dry lignite from the Liptol briquetting plant is supplied not only to thw Liptol- but also to the Ptolemais power station according to a proposal by the LCPA. In a second step this procedure is proposed for the Kardia power station as well. The strong influence of small reductions of the acceptable calorific value of the lignite production of the West Field South on the exploitable reserves and on the mining ratio has been shown. There are two options to achieve the necessary drying effect for a fraction of the lignite supplied to the Kardia power station. The power station can be equipped with steam separators (As the megalopolis power stations) or a separate lignite drying facility is to be installed.

Up to now the quality of the intercalations in unknown.in a multi layer deposit as in the case of PPC s deposits the reserves are, however considerably influenced by the quality of the intercalations. It is suggested to start an investigation of this matter as soon as possible.

This activity requires the co-ordinated action of mine planners and Power station expearts. Ist co-ordination should be assigned to DAO from our point of view.

6.1.3 The Utilisation of the Mine Equipment

The utilisation of the mine equipment is hampered by inappropriate design features at present (lack of theoretical capacity, lack of drive power). The planning of appropriate remedy measures and the procurement of spares needs possibly the support of DAO and co-ordination activities.

6.1.4 Lignite Sampling and Analysis

In order to avoid lignite losses and problems related to insufficient lignite quality in the power stations, the selective mining of lignite and intercalations needs to be monitored and steered according to the monitoring results.

This calls for the installation of facilities for continuous measurements of the quantity (belt scales) and of thquality of the lignite as a basis for the steering of the selective mining.

The results of these measurements together with the results of special masscalculations aiming to determine the quality of the undiluted lignite can at the same time be used for the determination of the quality andquantity of the diluting intercalations, which are unjknown up to now.

From our point of view this is a follow up activity to be carried out by DAO for all PPC mines.

6.2 Follow up Activities of the Internal Units (Planning Units in the Mines)

The mine planning facilities for the follow up activities described below are not available at present.

As proposed in the phase 2 of the Thalis Symphonia project, the implementation of internal mine planning units is an urgent matter. As we see it, it is not possible, to operate PPC s mines on a high level of equipment utilisation without these internal planning units. Additionally it is our opinion, that the guidelines of the TMMP will remain uneffective, until these internal mine planning units start to execute the TMMP in co-operation with DAO.

Nevertheless PPC appears not to have really adopted the methodology of mine planning described above.

In order to emphasise the necessity to do so again, some of the essential objectives for the mid- and short-term mine planning activities of the internal mine planning units in context with findings of the work of the Masterplan Team are presented below.

Apart from these mid and short term planning activities

There are follow up activities, which are to be carried out generally in every mine regularly. Additionally there are special problems in almost each of PPC s mines in the LCPa and in the LCM, which call for mid- and short-term planning actions. The objective of these follow up measures is

- to improve the performance of the mine equipment (Cost reductions) and
- to increase the safety of the supply of lignite to the consumers (Quantity and Quality).

6.2.1 General Problems

General problems, which cannot be dealt with in an aprropriate way at present are for instance the regular check up of the drive power requirements and the adjustment of the yearly mine planning to the seasonal changes of the lignite demand.

Drive power requirements:

The lack of drive power is an important operational constraint at present. This is one of the reasons why the load factor achieved up to now has remained below an acceptable level.

The drive power reqirements depend among others of the length and the lift of the individual conveyor sections. The lift of the conveyor sections cannot be determined once for ever, because the elevation of the benches is the most important tool for the regulation of the mine progress. Without adjusting the bench elevations regularly, the unhampered operation of the excavators and spreaders in a mine, the achievement of the yearly and monthly production targets cannot be ensured.

In order to keep the belt conveyor system equipped with sufficient drive power, the following standard procedure is normally applied:

- The bench elevations are adjusted yearly for the next five (in special cases up to ten years) until the accumulated quantities on the excavation and dump benches fesult in the yearly Iproduction targets and until the quantities on each bench correspond to the capacity of the machine on each bench.
- The drive power requirements are calculated subsequently.

At the same time the unhampered progress of each machine is ensured by this procedure and the demad of belt conveyor material for the next years is reviewed. Additionally a mid term schedule of operational events is developed as the basis for the co-ordination of these events with maintenance measures and for the planning of both activities.

It recommended to introduce the above described activities as a standard working procedure.

Seasonal Changes of the Lignite Demand:

In attachment [ATT 37] the seasonal changes of the generation of electricity have been analysed. We observed two peak load periods. From November to February and during July and August the generation of electriciy is higher than the yearly average. The winter peak is higher than the summer peak. Between the peak periods the net generation is below the average generation.

As soon as the general level of the utilisation of the base load capacity increases, these seasonal changes will become smaller. Nevertheless it is necessary to adjust the yearly mine planning to the changing lignite demand, which is the consequence of these changes.

The the capacity of the mines, to release lignite must be higher during the peak periods and lower during the valley periods. without these adjustments the stockpiles cannot fulfill their blending function appropriately.

In PPC s multi layer deposits it is not possible to create reserves of exposed lignite as a preparatory measure for the peak periods. Lignite and intercalations are to be excavated at the ratio found on each bench together.

The lignite release capacity can only be adjusted by adjustments of the eqipment capacity contributing to the lignite release.

The there are various measures to be applied in order to achieve a lignite release capacity, which varies according to the electricity generation of the Power stations:

- During peak periods the lignite releasing excavators operate with higher priority than the overburden excavators.
- It can be tried to keep operational events (belt shifting. extension of belt sections, transportation of excavators etc.) out of the peak periods.
- By adjustments of the bench elevations the ratio on the uppermost lignite releasing bench can be increased during valley periods and reduced during peak periods. This is a very effective adjustment of the excavator capacity contributing to the relese of lignite.

The actual variation of the lignite release requirements can only be assessed for a short period of time (Say one year). In this context the schedule of revisions of the power station units is important. It will never remain as set at the beginning of a year. The mine planning is to be adjusted according to these changes of the schedule of operation for the power station.

It is obvious, that this kind of activities require more mine planning capacity than available at present. The negative effects which are to be accepted, if these activities cannot be executed are obvious too.

6.2.2 LCPA

Until 2020 the LCPA will be subject to considerable changes. A complex time schedule is to be designed and steered. According to our experience this possibility can only be achieved by the regular review of a detailed bench wise mid- and short term mine planning.

The special events on the time schedules of PPC s mines will be mentioned below.

6.2.2.1 LCPA - North Field

The North Field is one of the two lignite suoppliers for the Liptol and Ptolemais Power stations according to our concept of development. Its equipment is to be transferred to the West Field North within a mid term period of time after the exhaustion of ist reserves. The same applies to the Komanos mine.

In order to expand the period of time for this activity the exploitation of the North Field is to be expedited. At the same time the increased lignite release by the North Field allows to reduce the mining ratio in the Komanos mine, which is to release the major fraction of the Liptol and Ptolemais lignite demand during the development of the West Field North. This applies especially to the expit dump N° 2, where at the same time overheights can be removed by a contractor.

The transition of the North Field equipment requires for a time schedule. It is suggested to develop a benchwise mid term planning until the completion of the North Field. In order to allow for the activities in the Komanos mine mentioned above, the highest achievable level of utilisation is to be applied. Prior to the start up of the operation of the North Field equipment in the West Field North it is suggested to overhaul the equipment. An appropriate period of time for this overhaul (according to the results of a checkup by PPC s mechanical and electrical engineers) is to be taken into account for the schedule of development of the West Field North.

6.2.2.2 LCPA - Komanos

According to the concept of development for the North Field described above, the Komanos mine is to remove as much overburden as possible especially in the area of the expit dump N°2 (Contractor) until the North Field reserves are exhausted.

Under this precondition the Komanos mine will be in the position, to release sufficient lignite after the exhaustion of the north Field reserves until the Westfield North development has been completed, the first sectors of the west Field North, which have a high mining ratio, have been exploited and the capacity of the Liptol and Ptolemais Power stations has been reduced. Only one Ptolemais unit will be still operating,when at the end of this period of time the Komanos reserves will be exhausted.

The steering of the Komanos mines according to the changing objectives described above requires a benchwise mid term planning for a five years period, which is to be reviewed yearly. close to the exhaustion of the Komanos reserves, the schedule for the transition of the Komanos equipment to the West field North is another objective of this planning.

6.2.2.3 LCPA - West Field North

The detailed bench wise planning of the West Field north is an urgent matter. When the work of the Masterplan Team commenced the first lignite from the West Field North was scheduled for 1997. Our present schedule calls for the first lignite from the West Field North for the year 2000, one year before the Komanos reserves will be exhausted. The preceding mine development is to begin in 1998.

In context with the development of the West Field North, the design of the energy supply for this new mine by PPC s electrical engineers has been initiated. This development is scheduled to begin with the employment of an excavator plus spreader and belt conveyor material from the Amyntaion mine. PPC s engineers regard it impossible, to prepare the energy supply for the West Field North by 1998.

A decision about the Amyntaion eqipment is still pending. Nevertheless it is necessary, to initiate the planning of this transportation of the aforementioned equipment just now.

It is too late for the specification and the procurement of new equipment and this solution is not regarded economical.

As we see it the capacity of the Amyntaion equipment cannot be substituted by a contractor without problems. It is not easy, to load and transport about 23 [Mm^3/a] crossing a public road.

There is, however, an option, to postpone the start up of the development of the West Field North and possibly the employment of amyntaion equipment in the West Field North as well by the supply of dry lignite to the Ptolemais power station. This requires, however, the following sequence of actions:

- General decision about the supply of dry lignite to the Ptolemais power station base on an investigation of the economical feasibility (We suggest to use support by RE. There was a contract about the supply of dry lignite to the Kardia Power station in the Past, which has not been executed for unknown reasons. RE is familiar with the problem).
- Design and installation of transportation facilities from the Ptolemais briquetting plant to the Ptolemais power station.
- Design and installation of facilities for the blending of dry lignite with teh mine production supplied to the Ptolemais power station (Lignite sampling and analysis, See section 4 of this report)
- Rewiew of the masscalculations and the subsequent long term mine planning for the the North Field, Komanos and the West Field North.
- Preparation of the aforementioned mid term plans for the North Field, Komanos and the West Field North.

This seqence of actions includes long-term planning activities (External unit) and mid-term planning activities by the internal unit.

6.2.2.4 LCPA - Sector 6 & West Field South

In the Sector 6 & West Field South mine a multiltude of co-ordination requirements is to be dealt with.

During the exploitation of the Sector 6 a relocation of the belt distribution point is to be carried out.

The relocated distribution point of the sector 6 will be used for the exploitation ofthe West Field South after the exhaustion of the sector 6 reserves. This opportunity is achieved by the relocation of th Soulöou creek. The alignment for this relocation is to be prepared in time by an co ordinated operation of the internal dumps of theSector 6 and the South Field

The relocation of the belt distribution point of the Sector 6 calls for an extended bench wise mid term planning (Ten instead of five years) as soon as possible

Aside of the Ptolemais and Liptol power stations the Kardia power station is another consumer of PPC lignite, where a calorific value above 1 300 [kcal / kg] has been specified. The supplier of lignite is the Sector 6 & West Field South. Additionally the lignite in the safety pillar of the Ptolemais and Liptol power stations is to be delivered to the Kardia power station, whereas the lignite in the safety pillar of the Kardia power station will be dlivered to the Agios Dimitrios power station, where the specified calorific value is lower.

1 200 < Lower Calorific Value [kcal / kg] < 1710.

The evaluation of the safety pillar of the Kardia power station according to the calorific value specified for the Agios Dimitrios power station instead of the Kardia power station resulted in considerably increasing reserves and a decreasing ratio.

Accordingly the option, to dry a fraction of the lignite supply for the Kardia power station, in order to achieve the same effects for the whole Sector 6 & West Field South should be investigated from our point of view-

6.2.2.5 LCPA - South Field

In the South Field the progress of the intermal dump needs to be reviewed and adjusted. in principle it has been introduced to early. Additionally the the relocation of the belt distribution point is to be steered based on an extended mid term planning (Ten instead of five years).

6.2.2.6 LCPA - Amyntaion

The special problems in the Amyntaion mine, which need the steering by a mid term planning are the increasing depth of the mine and the early introduction of the internal dump.

According to the masscalculation by the Masterplan Team the mine bottom is generally deeper than assumed up to now. An appropriate adjustment of the mid-term mine planning is urgent. A part of the lignite deposit could be left unexploited by the last bench, for the more expensive exploitation by conventional equipment.

In the Amyntaion mine the critical mine position is reached extremely late. Due to Geomechanical considerations the early start up of internal dumping is, however necessary. In this situation the progress of the internal dump needs regulation by the regular review of the mid term duing plans.

6.2.3 LCM

In the LCM the situation is not as complicated as in the LCPA.

Mid-term planning requirements are related to the status of development of the Horemi mine.

In the Goergen Study the necessity to blend the different lignite qualities in the northern of in the southern part of the deposit have been emphasised. As we see it, this does not apply. Corresponding to the decreasing power station capacity the lignite production should be concentrated on the Horemi mine.

6.2.3.1 LCM - Horemi

In the Horemi mine the volume of the expit dump is almost consumed at present. At the same time the development of three excavation benches and three benches of the inpit dump is still pending. This development is to be completed prior to the complete consumption of the expit volume.

The achievement of this target can be achieved by operating the existing three excavation benches with an increased excavation height at low priority. The misiing three benches are to be developed and then operated with the highest possible priority. The same applies to the benches of the inpit dump.

The execution of this concept calls for an extended bench wise mid-term planning for the Horemi mine.

6.2.3.2 LCM - Marathousa

In the Marathousa mine our long time concept is already based on a rough bench wise masscalculation, because a mine depth for four excavators is excavated by two excavators only. After all benches in the Horemi mine have been installed the Marathousa mine is to proceed wit high priority. In order to support the perimeter slope of Marathousa with an inpit dump and to increase the insufficient dump volume for ash in the former Thoknia mine, the final void of the Marathousa mine will be completely filled up with ash and Horemi waste.

The necessity to schedule and steer these activities by a regularly reviewed mid term planning need no further clarification.

6.2.3.3 LCM - Kyparissia

After having achieved the targets described above for Horemi and Marathousa, The exploitation of the remaining Kyparissia reserves is to be expedited (Co-ordination of the mid-term planning in Horemi and Kyparissia).

7.3 Reference Documents referring to General Technical Matters

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20. Memo; Subject: Power Supply for the West Field North

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31.

N°	Code	Date	Title	Scale
43	BL- 0 / 0/ 43	14.12.95	Position of the mine 2002	1 : 5 000
44	BL- 0 / 0/ 44	14.12.95	Position of the mine 2004	1 : 5 000

7.2.1.6 Large Format Drawings - LCPA - Proastion

N°	Code	Date	Title	Scale
1	L- 1 / 0 / 01	09.08.94	Open pit boundary	1 : 10000
2	L- 0 / 0 / 02	27.10.94	Technical top	1 : 10000
3	L- 0 / 0 / 03	27.10.94	Economical bottom	1 : 10000
4	L- 0 / 0 / 04	27.10.94	Exploitation ratio (A : K m³/ t)	1 : 10000
5	L- 0 / 0 / 05	01.10.94	Map of drilling site with lines of intersection	1 : 10000
6	L- 0 / 0 / 06	01.10.94	Geological cross - section with tech. top + econ. bottom	1 : 10000
7	L- 0 / 0 / 07	17.02.95	Map of drilling site with suggested boreholes	1 : 10000
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7.2.1.7 Large Format Drawings - LCPA - Amyntaion

N°	Code *)	Date	Title	Scale
1	A -1 / 0 / 01	16.08.94	Open pit boundary of Amyntheon with Lakia including	1 : 10000
2	A- 1 / 1 / 02	26.08.94	Sectors of excavation side	1 : 10000
3	A- 5 / 1 / 03	01.09.94	Sectors of dumping side including Lakia Variant 1	1 : 10000
4	A- 5 / 1 / 04	01.09.94	Sectors of dumping side without Lakia Variant 2	1 : 10000
5	A- 0 / 0 / 05	19.07.94	Map of drilling site with lines of intersections	1 : 10000
6	A- 0 / 0 / 06	01.10.94	Geological cross-section 1- 23 with tech. top + eco. bottom	1 : 10000
7	A- 0 / 0 / 07	26.10.94	Technical top	1 : 10000
8	A- 0 / 0 / 08	26.10.94	Exploitation ratio (A : K m^3/t)	1 : 10000
9	A- 0 / 0 / 09	26.10.94	Economical bottom	1 : 10000
10	A- 1 / 2 / 10	03.11.94	Open pit boundaries Amynteon with Lakia separately	1 : 10000
11	A- 1 / 0 / 11	14.12.94	Level and sectors for the 1st bench	1 : 10000
12	A- 1 / 0 / 12	15.12.94	Level and sectors for the 2nd bench	1 : 10000
13	A- 1 / 0 / 13	16.12.94	Level and sectors for the 3a bench	1 : 10000
14	A- 1 / 0 / 14	16.12.94	Level and sectors for the 3b bench	1 : 10000
15	A- 1 / 0 / 15	17.12.94	Level and sectors for the 4th bench	1 : 10000
16	A- 1 / 0 / 16	17.12.94	Level and sectors for the 5th bench	1 : 10000
17	A- 1 / 0 / 17	19.12.94	Economical bottom and sectors for the 6th bench	1 : 10000
18	A- 5 / 0 / 18	17.02.95	Development of the 1st dumping bench by section	1 : 1000
19	A- 5 / 2 / 19	01.03.95	Concept of reclamation inside dump	1 : 10000
20	A- 5 / 3 / 20	01.03.95	Sectors of dumping side Variant 3	1 : 10000
21	A- 5 / 0 / 21	20.02.95	Development of the 1st dumping bench	1 : 1000
22	A- 1 / 0 / 22	18.04.95	Suggestion for the operational level of the last bench	1 : 5000
23	A- 0 / 0 / 23	17.02.95	Map of drilling site with suggested boreholes	1 : 10000
24	A- 0 / 0 / 24	28.03.95	Land demand for the excavations	1 : 10000
25	A- 0 / 0 / 25	29.03.95	Surface reclaimed from the inside dump	1 : 10000
26	A- 0 / 0 / 26	07.04.95	Surface reclaimed from the outside dump	1 : 10000
27	A- 0 / 0 / 27	07.04.95	Land demand for the outside dump	1 : 10000
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