SEA-SHORE-ROSEN LTD.

COASTAL, HARBOUR & MARINE ENGINEERING
PLANNING, CONSULTING, SUPERVISION

ים-חוף-רוזן בע"מ

הנדסת חופים, נמלים וימית
תכנון, יעוץ, פיקוח

STUDY ON THE OPTIMUM SITE LOCATION OF THE OFFSHORE INTAKE HEAD FOR ASHKELON DESALINATION PLANT, BASIC DESIGN AND DEFINITIONS.

FINAL REPORT

Haifa, February 01, 2002

IDE technologies ltd.

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PARTNERSHIP

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REPORT TEXT

1. INTRODUCTION

Following an offer submitted by Sea-Shore-Rosen Ltd. (SSR) to IDE Technologies Ltd. (IDE) on 7 November 2001, and a meeting held at IDE offices in Raanana on November 19, 2001 with the participation of Eng. G. Haran and Eng. A. Kaplan from IDE, Mr. Thomas Reid from Vivendi Group and the author on behalf of SSR, the O.T.I.D. Desalination Partnership, requested SSR to study and recommend the location of the offshore intake head for the Ashkelon desalination plant, under Purchase Order No. 10003/66176, dated December 2, 2001 and received via fax on December 05, 2001, based on SSR's updated offer of November 20, 2001. O.T.I.D have been awarded the first Israeli BOO contract for a 50,000,000 m^3/year desalination plant at Ashkelon coast by the Government of Israel (meanwhile increased to 100,000,000 m^3/year). The plant will be located within the port coastal area of the Eilat-Ashkelon Pipeline Company (KATZA), on the area reclaimed just South and adjacent to the root of the main breakwater of the Israel Electric Corporation (IEC) Rutenberg Power Station. The initial design of a single intake head was later changed by the client to two intake heads and two intake pipelines. The intake pipelines and intake heads would be located within the marine premises of the Ashkelon Oil Harbour (see Figure 2). Based on SSR's offer, the work started on December 25, upon receipt of the advance payment for the works.

The design intake discharge considered was based on a maximum discharge value of 18,500 m^3/hour as specified by Eng. Avigdor Kaplan of IDE in his fax dated December 10, 2001. This fax included also a number of additional data to be considered (regarding sedimentation, physical, chemical and biological status). Additional information received at later stages a digital file with an aerial photography taken on September 23, 2001 covering the area of interest (see Figure 2) purchased by IDE according to author's recommendation from Ofek Aerial Photography Ltd., and TSS analyses of a number of 3 sea water samples taken in November 2001 off Katza coast.

This report presents the scope and the outcome of the ordered study, dealing with the determination of the optimum location of the desalination water intake heads in the surroundings of the allocated site for the desalination plant at the Ashkelon Katza harbour, assuming that a common intake type will be used.

2. SCOPE OF WORKS

The scope of works of the study included three major tasks (Sections 2.1 – 2.3 of the SSR offer) which are described below, and a fourth one included the preparation of this report. Preliminary reports covering sections 2.1 and 2.2 were submitted to the client in the past. For the sake of completeness these will be repeated in this report, including updates, when necessary.

The scope of the first task was according to Section 2.1 of SSR's offer, dealing with the preliminary study of potential locations and sites based on a common intake type and included the proposal by SSR of a number of alternative locations and layouts to IDE for the intake head of conventional type, explaining their attributes and drawbacks, including preliminary recommendations. The proposal of the sites was based on author's general knowledge of the local conditions at Katza, Ashkelon from previous studies conducted in this coastal sector as well as on the Mediterranean coast of Israel regarding meteoceanographic conditions, bathymetric conditions, bottom properties, sediment transport climate, as well as based on an updated review of existing information at SSR and from the IDE and additional sources to indicated to the client by SSR and from some quick desk studies.

The scope of the second task included preparation of guidance for gathering lacking information and data for the study, namely:

a. Guidelines for bathymetric, sub bottom and topographic surveys and for aerial photographs
b. Guidelines regarding soil properties tests in the study area and in particular at the site of the contemplated alternatives and their pipeline layouts .
c. Guidelines for characterization of the sea-water quality (pollutants, pollution sources, installations and potential polluting sources), marine fauna and biota (including jelly-fish, fish, phytoplankton, etc.).

d. Additional guidance for gathering new data on the meteoceanographic environment in the area, such as currents, waves, sea-levels, wind from various proprietary sources, such as Israel Oceanographic & Limnological Research, Meteorological Service, etc.

The scope of the third task included the study of the local marine conditions at up to three sites selected by the client for the intake head (from those proposed by the first task progress report) from the point of view of the determined local wave and current climate, from the point of view of the local predominant and prevailing suspended load conditions, from the point of view of the sea bottom bathymetry and sub-bottom (sand, kurkar, silt, clay), from the point of view of safety (to the intake head and pipeline and to navigation) and from the point of view of environmental impact. The outcome would enable the selection of some of the design values of various parameters, further in the design and tendering process for the construction of the intakes heads and pipelines.

3. OUTCOME OF THE STUDY WORKS IN TASK 1

The outcome of the works performed for the study is presented below.

3.1 Considerations for the selection of the site of the intake head of the desalination plant

The major purpose of the study ordered as understood by the author has been to select the optimum location of the head of the intake pipeline of the desalination plant in respect to the installation, operation and maintenance of the whole intake with:

a. Minimum obstructions to the sea water flow,
b. Minimum long term suspended matter (organic and non-organic) trapping,
c. Best survivability and lowest cost in regards to its structural survivability and maintenance,
d. Minimum obstruction to shipping and/or other floating hazards,
e. Cleanest seawater.

To enable to find the optimum site meeting the above requirements, one needs to get acquainted with the environmental characteristics of the contemplated area for the intake head. Consequently below we will first review shortly the presently known characteristics of the Ashkelon coast, as well as of its potentially affecting neighbor area, the Sinai and Gaza coast.

3.2 Description of the coastal area within which the intake head will be located

The coastal area selected by the Israeli Government for the desalination plant is located in the southern part of the Mediterranean coast of Israel. The coastal face extending from the Nile Delta to Haifa Bay (Figure No.1), was identified by Emery and Neev (1960) as belonging to a large sedimentary unit, named the “Nile Littoral Cell” by Inman and Bagnold (1963). This is due to the fact that the majority of the sediments covering its coasts originate from the Nile River, as indicated by the large content of "nilotic" (quartz material) sand, versus the low content of local biogenic (carbonate material) sand, produced by shells and some local river outflows. Hence, as indicated by the quartz sand presence, the long term net sediment transport in this cell is moving northward parallel to the coast. Hence, it is obvious that any developments in this cell would be influenced by their predecessors upstream the longshore sediment transport flow and would be influencing the coast downstream that flow. The sediment transport is been done in a combination of the three following modes:

(a) Within the surf zone, reaching from the waterline to water depths of between –2m to –5m in average stormy years and up to –7m or more in extreme stormy years, the currents transporting the sediments are wave induced currents, and the peak of the sediment transport occurs at about 2/3rds of the width of the surf zone, measured from the waterline.

(b) Beyond the surf zone, the major currents are induced by the general geostrophic circulation and by the wind. The transport of the sediments alongshore occurs due to a combined action of the currents and waves, whereas the waves stir the sediments from the sea bottom into suspension, and the currents transport the suspended material even when weak.

(c) In addition to the longshore transport, cross-shore (onshore or offshore) may concomitantly occur, with strength dependent on the waves characteristics and wind characteristics. Waves again are the major contributor for the cross-shore transport in the surf zone, while in the offshore zone the contribution of the wind to the general current can strengthen the longshore current of the sediments longshore, or their absence can facilitate deposition.

As a general rule, sand (62 microns to 4 mm diameter) is found up to a water depth of about 30m, and beyond that a mixture of mostly silt and further clay is found on the upper layer of the sea bottom.

From about –25m depth to about –30m the bottom sediment is composed of a mixture of sand and some amount of silt, and its composition changes gradually to mainly silt at about –30m to –35m depth. Sand sizes are know to decrease along the coast from Sinai to Tel Aviv, with a median diameter of about 250microns at Ashkelon in the surf zone, with coarser sands at the foreshore and in the summer surf zone, and finer sands further offshore (about 125 microns beyond –15m contour line). The actual site location of KATZA coast is shown in Figure 2. A typical cross-shore profile of the longshore sediment transport on the southern part of the Israeli coast, applicable also for KATZA coast is shown in Figure 3a. A profile of the coast just South of Katza based on a recent mapping survey is shown in Figure 3b.

The preliminary general wave characteristics used for the first task were based on older measurements, gathered via visual and afterwards waverider buoy off Ashdod. These were updated in task three based on both older and newer data (Rosen, 1998; Glozman, 2000).

WINDS

The preliminary general wind characteristics used for the first task were based on older measurements assessed based on data from Gaza and from Ashdod. New data became available from the EIS report of the Liquid Chemicals Terminal at Katza (Paz Engineering and Management, 2000). However, the major characteristics remain similar, hence we repeat here the information provided in the progress report (Rosen, 2002a).

Table 1 – General Wind Characteristics

Average Year Intensity Distribution

light winds (less than 10 knots)	**~ 81.4 percent of time**
fresh winds (11 to 21 knots)	**18.3 percent of time**
strong winds (22 to 33 knots)	**1.2 percent of time**
winds above 33 knots	**< 0.1 percent of time**

Average Year Directional Distribution:

77% of the **fresh** winds blow from directions W to N through NW.

77% of the **strong** winds blow from directions SW to W trough WSW.

Average Seasonal Distribution:

94% of the **strong** winds occur between November and March, and
60% of the **strong** winds occur in January and February.

WAVES

The preliminary general wave characteristics used for the first task in the progress report (Rosen, 2002) are repeated below. Updated characteristics will be presented later in the report.

Average Year Deep Water Characteristic (Significant) Wave Height Distribution:

low sea states (less than 1 m)	50.0 percent of time
moderate sea states (between 1 m and 2 m)	25.0 percent of time
strong sea states (between 2 m and 4 m)	20.0 percent of time
high sea states (above 4 m)	5.0 percent of time

Average Year Directional Wave Distribution:

All moderate and higher sea states come from WSW to NNW through W

66% of all waves approach from W trough WNW directions.

The highest sea states approach from W direction, but storm development occurs by veering from WSW to NW trough W directions.

Peak Wave Periods:

Peak wave periods range between 3 and 15 seconds. During high sea states they range usually between 10 and 13 seconds, and very high sea states have peak periods between 12 and 15 seconds.

Extreme sea states vs their average return periods and corresponding inshore wave heights

Estimation of extreme wave conditions were based on Rosen and Kit (1981). Assessment of the corresponding refracted wave heights at three water depths was later derived, using wave refraction software package ACES of the US Corps of Engineers. These are shown below in Table No.2, and the extreme wave heights assessment in deep water is shown in Figure 4. The wave refraction was performed assuming deep water wave approach for these high sea states from West, taking into consideration the coast and contour lines orientation at Katza coast (Azimuth of perpendicular to contour lines = 304 degrees).

Table No.2 - Extreme sea states

Water depth contour	Deep Water	-20 m	-17.5 m	-15 m
Average Return Period	Significant wave height	Estimated refracted significant wave height		
[years]	[meters]	[meters]	[meters]	[meters]
2	5.15	5.05	4.97	5.32
4	5.95	5.74	5.89	5.88
5	6.15	5.53	5.60	5.70
6	6.25	5.61	5.69	5.79
8	6.60	5.96	6.04	6.15
10	6.80	6.15	6.23	6.35
15	7.15	6.47	6.56	6.69
20	7.40	6.70	6.79	6.93
50	8.20	7.50	7.60	7.75
100	8.70	8.00	8.13	8.31
500	10.15	-	-	-

Estimated extreme relationship between maximum and characteristic (significant) wave height in a given sea- state: $H_{\max} = 2 \cdot H_{m_o}$ and the dependence of the design wave height on risk and structure economic lifetime is given in Table 3 in the next page:

Table No. 3 - Dependence of the design wave height on risk and on structure economic lifetime

Accepted Risk to Encounter Design Wave	Economical Life Time of Structure (years)						
[percentages]	2	4	6	8	10	15	20
	Average Return Period to be Used						
1	200	398	597	796	995	--	--
5	39	78	117	156	195	293	390
10	19	38	57	76	95	143	190
20	10	18	27	36	45	68	90
50	4	6	9	12	15	22	29
64	2	4	6	8	10	15	20

For example, the meaning of the information given in Table 3 above means that if the economic lifetime of a certain marine structure, say an intake head, is assumed as 20 years, and we accept a risk of maximum 5% that the design wave height would be exceeded during the economic lifetime, the design wave height to be selected is that with an average return period of 390 years. The deep water significant wave corresponding to this is read in Figure 4, about 10.1m.

The average duration of storms is taken from Rosen (1998) and is given in Table 4 below.

Table No. 4 - Average Yearly Number of Storms and Their Average Duration:

Sea State of the Storm Crossing the Specified Level

Sea State Exceeded Hmo>=	Average No. of Storms	Average Duration of the Sea State per Storm	Standard Deviation of the Storm Duration
[m]	[-]	[hours]	[hours]
0.5	79.34	90.5	127.31
1.0	59.63	39.7	44.15
1.5	33.56	35.2	35.33
2.0	24.90	29.2	29.26
3.0	9.90	24.4	20.00
4.0	5.10	16.2	13.43
5.0	1.25	12.2	9.40
6.0	0.25	5.3	4.76

SEA LEVELS AND TIDES

Tidal range varies between 0.4 m during spring tides, and 0.15m during neap tides. Extreme sea levels may occur in combination with extreme meteorological conditions. Based on 30 years of data, the following average return periods are assessed in Table 5.

Table No. 5 – Estimate of extreme sea levels

Average Return Period [years]	Low Sea Level [m]	High Sea Level [m]
1	-0.41	0.60
50	-0.79	1.00
100	-0.90	1.06

The above values do not include the expected sea-level rise due to the "greenhouse effect", for which the assessed values for 2100, range between 0.5 m and 1.0 m. Presently a sea level rise of about 10 cm has been detected from 1992 to present by the author, based on data gathered at Hadera GLOSS station 80. Similar rates for the Eastern Mediterranean were derived via satellite altimetry by foreign scientists. Even though it is not yet clear if this represents a decadal fluctuation or a true global warming induced sea level rise, this aspect should be carefully considered in the design of desalination plant.

CURRENTS

Tidal Currents:

Tidal currents in this region are in general weak, in the order of about 5 cm/second.

Wave Induced Currents:

These currents prevail and are predominant within the surf zone. Longshore currents are induced by waves approaching obliquely to the contour lines, and flow parallel to the shore line. Rip currents are generated by perpendicular waves or edge waves, and flow from the shore offshore, almost perpendicular to shore line to a distance of up to about 3 times the surf zone width, within which they decay completely. The former may attain during storms speeds of 4 knots and even more, The latter may also attain 1 to 2 knots, but also in calmer sea states.

General Circulation:

In this region, the general circulation, due mainly to the geostrophic current and shelf waves, is oriented counter clockwise most of the time. The currents in most cases have low speeds of about 10 cm/sec. The vertical distribution is almost uniform in winter, but decays towards the bottom in summer. The speed decreases towards the shore. In certain instances, currents of about 2 knots were measured. Yearly current statistics off Katza coast in 27m water depth, based on one year of continuous measurements is presented in Figure 5 (Rosen, 1998).

For a better understanding of the characteristics of the area, the history of the developments in the coastal sector of Gaza to Ashkelon is given below:

Between fall 1973 and summer 1974 a service harbour (Katza) for Eilat-Ashkelon oil pipe-line was built at Zikim, some 10km south to Ashkelon, with its entrance in -3m water depth. To protect it against silting, two groins were built, one north of the harbour, only 80m long, in 1974, and another one to the south, 160m long in 1975. Sedimentological changes resulted almost immediately. In fact the erosion to the north was so significant that the beach rock was exposed, and in order to prevent further beach erosion a rubble mound low coverage was placed there.

In 1986 a few short sea-wall sections were built between the northern groin and the Katza service harbour to protect the cliff against erosion. Afterwards, during 1987-1988 the cooling basin of the Rutenberg power station was built as a new main breakwater and groin, 350m to the south of the root of the main breakwater of the service harbour, in the shape of the Greek Γ letter extending to a water depth of -5.5 m at the corner and covering the main breakwater of the service harbour, reaching there a water depth of about -7m at the head toe.

During 1997 a fishing port was built off Gaza coast, extending with its breakwater head to a water depth of about -5.5m. Significant sedimentation resulted to the south of the harbour. Erosion immediately north to it was not visible at the beginning, as the coast there was protected by shallow coast parallel breakwaters built in the 1970's. However, presently significant erosion occurred north to the port, while significant accretion occurred south to it, as the detached breakwaters were dismantled and used in the construction of the lee breakwater of the Gaza fishing harbour. The Gaza coast is important for the desalination plant also in view of the fact that most of the city sewage is flowing to the sea, to our knowledge mostly untreated.

A series of bathymetric surveys were conducted in the area between 1976 and 1995 determined the formation of four canyons in the sea bottom off the Rutenberg power plant. These run in a west-east direction, starting at a water depth of about 27m or less with their heads reaching a water depth of 6m. The canyons developed next to the oil pipelines of KATZA, and there is little doubt that their formation is related to these pipelines. The southern canyon heads to the main breakwater of the cooling basin and its position drifted northward with time. As shown by Golik and Rosen (1999), about 1.2 million m^3 of sand was trapped on the flanks of their trenches, in an area of 1.2 km^2 for which coverage of redundant surveys was available. In fact, the area of deposition is probably much larger and it is estimated that the volume of sand trapped is at least two times as much. During 1999-2000 the IEC reclaimed a portion of the sea area adjacent to the main breakwater of the cooling basin and used it as stocking and work area for the construction of a new coal terminal (This is presently the area planned to be used for the desalination plant).

During 2000-2001 a coal unloading trestle and open berth on piles was built south to Rutenberg cooling basing, but its obstruction effect to sediment transport is yet not known, although it is estimated to be insignificant on the basis of the experience obtained with the similar structure built at Hadera cooling basin in 1980-1982.

The assessments of sediment transport rates for this region are described below:

Gaza coast

A number of sediment transport assessments were performed for the Gaza coast. The first is the assessment conducted by Migniot and Manoujan (1975), in regards to the design of the Hadera cooling basin. Using the LCHF sediment transport formula, with a coefficient calibrated based on Tunisian beaches (Migniot, 1985 - personal communication), and wave data derived from the visually observed wave data at Ashdod, they assessed the following net (parallel to the coast, northward directed) yearly average sediment transports: at Gaza - 400,000 m^3/year, at Ashdod - 215,000 m^3/year and at Hadera - 100,000 to 150,000 m^3/year.

Another assessment was performed by Portconsult for a fishing port at Gaza (1987), which estimated the volumes given in Table No. 6.

Table No. 6 – Sediment transport assessment by PortConsult (1987)

Site	Northward	Southward	Net
	m^3/year	m^3/year	m^3/year
Gaza	400,000	-40,000	360,000
Ashkelon	567,000 ±128,000	-301,000±55,000	270,000

According to verbal information the assessment was based on visually derived wave data from Ashdod and Ashkelon and wind data from Gaza. Finally, in regards with a major port requested by the Palestinian Authority to be built at Gaza, Delft Hydraulics conducted two studies, first (Delft Hydraulics, 1994) using Unibest model (one-line model) and later (Bosboom, 1996) with the Delft 2D-MOR model. The wave data were hindcasted wave data from wind data as well as some Ashdod wave data.

The assessments obtained using Bijker formula are given in Table No. 7:

Table No. 7 - Sediment transport assessment with Bijker formula

Site	Northward	Southward	Net
	m^3/year	m^3/year	m^3/year
Gaza (UNIBEST)	510,000	-160,000	350,000
Gaza (Delft2DMOR)	455,000	-95,000	360,000
Ashkelon	-	-	300,000

They also have shown that for Gaza, using various formulas the following results were obtained and selected Bijker formula as the most reasonable one:

Table No. 8 – Net sediment transport assessments at Gaza

Formula	Baillard	Bijker	Van Rijn
	m^3/year	m^3/year	m^3/year
Net yearly at Gaza	170,000	-350,000	540,000

It should also be mentioned that in using the Delft-2D-MOR model, the values above were obtained with the Fredsoe bottom stress model (Fredsoe, 1984) which was considered to provide more reliable results, while using the Bijker (1967) bottom stress model about 40% lower values were obtained.

Ashkelon coast

For the Rutenberg cooling basing sedimentological assessments were performed by Finkelstein (1984) and by Vajda and Finkelstein (1984). The assessments were performed using a number of formulas and Ashdod wave data (1958-1981) and their statistics (all visually observed wave directions) and are given in Table No. 9 below:

Table No. 9 - Sediment transport assessments at Ashdod

Formula	Northward	Southward (-)	Net
	m^3/year	m^3/year	M^3/year
Engelund-Hansen	4,000,000	-300,000	3,700,000
CERC	2,000,000	-150,000	1,800,000
SWANBY	1,100,000	-90,000	1,010,000
Bijker (no currents)	950,000	-75,000	875,000
CAMERI	740,000	-65,000	675,000
LCHF	400,000	-35,000	365,000

They concluded that the situation in 1980-82 is a new sedimentological equilibrium state, which led to various changes on the beach and bottom within 1km on each side of the service harbour. The total volume trapped was estimated at 200,000 m^3 with some 40,000 m^3 eroded north of Katza. Based on a physical sedimentological model, it was estimated that as a result of the construction of the cooling basin, a yearly maintenance dredging of 10,000 m^3 will be needed, as well as an initial 60,000 m^3 dredging. It was estimated that a new equilibrium state will be reached within 5 years from the construction of the cooling basin, leading to an additional deposit of 170,000 m^3 to the south of the cooling basin and some 50,000 m^3 erosion in the shallow water north to the cooling basin.

An assessment of the longshore transport at the site of the Ashkelon marina coast a few km north to KATZA was given by Verner (1986) and is shown in Table 10:

Table No. 10 - Sediment transport assessments at Ashkelon by Verner (1986)

Northward	Southward	Net
m^3/year	m^3/year	m^3/year
740,000	-65,000	675,000

Another assessment of the sediment transport at Ashkelon was performed by Jensen (1990), in regards with the design of the Ashkelon marina. Based on Delft Hydraulics (1994) their assessment was of a net transport northward of about 250,000m^3, with negligible southward transport. The assessment was based on the visual wave data from Ashdod (1958-75).

Finally, the author (Rosen, 1999) assessed a long term yearly average net transport at Ashkelon of about 350,000 m^3.

3.3 Proposal of alternative sites for the location of the sea water intake head.

Based on the above information, on the bathymetry of the area (see Figure 2), on the present and future marine activities in the area (laying of the gas pipe-lines, construction of the chemicals offshore terminal) and on additional information described where applicable, in the following a number of alternative sites have been proposed, together with their apparent attributes. A basic condition for prevention of suspended organic or anorganic matter trapping would require small water flow velocities at the intake face, preferably less than 5cm/s and not larger than 10cm/s. This of course would impose a relatively large intake head flow area, namely a relatively large diameter area, if the intake head structure height is limited. The deeper the water depth at the location of the intake, the higher the possible intake height, leading to smaller intake diameter and hence to reduced drag and lift forces on the intake structure. These forces are approximately directly proportional to the square of the intake diameter.

<u>Site A</u>

This alternative proposes to locate the intake head within the cooling basin of the IEC Rutenberg Power station cooling basin.

The attributes would be a shorter length of the intake pipeline, calm conditions prevailing most of the time of the year, facilitating settling of sediments prior to their arrival to the intake head.

The drawbacks are the relatively small depth of the basin, the increased flow of water trough the basin entrance, able to trap more sediments and hence requiring more frequent dredging operations, the nearby presence of ships which may pollute the basin from time to time, trapping of jelly fishes during their appearance periods.

<u>Site B</u>

Based on the sediment transport characteristics, it is obvious that the intake head if not located in a protected environment as in Site A, must meet the conditions mentioned earlier in this report.

Correspondingly this site is proposed on the southern part of the tresle of the new coal unloading terminal at the position where the water depth is 15m. Locating it near the trestle would provide partial protection to the intake from ships, which if located on the northern side of the trestle would have a large risk of accidental damage to it, assuming the intake structure would be elevated at least 5m above the bottom, and higher less than 5m. This is perhaps less than formally required by IDE (7m to 10m below surface) but perhaps sufficient if vessels would be prevented to access the area by a series of breasting dolphins. The water could be raised from the intake head to the pipelines layed on the trestle, from where they could flow by gravity till the desalination plant. In this way only minimum pipeline protection and maintenance would be necessary.

The drawbacks of the site are the longer pipeline length, the perhaps yet small water depth which may still have a significant portion of suspended sediments. Also, pollution flowing along the coast from Gaza coast may be present in this area. Also, as indicated by a recent study of the content of the coastal waters of Israel, at water depths less than 10 m, and in particular in the south, presence of microalgae capable of toxic red tides was found in large concentrations. It is not clear it at that distance these microalgae are yet in significant concentration.

Site C

This site is similar to Site B, but located at a water depth of 17.5m, near the southern side of the coal terminal trestle. For this case the attributes are the same as for Site B, and in addition the intake head could be further elevated to about 7.5m above the bottom, leaving at least 5m free vessel passage safety for the structure of the intake head.

The drawbacks are similar to Site B, but the length of the pipelines further increases, while the chance of getting pollution from the Gaza coast decreases.

Site D

This site is similar to Site C, but located at a water depth of 20m, near the southern side of the coal terminal trestle. For this case the attributes are the same as for Site C, the intake head can be elevated to about 10 m above the bottom, leaving yet at least 5m free vessel passage safety for the structure of the intake head. The increased elevation would further decrease the trapping of suspended sediments.

The drawbacks are similar to Site B, but the length of the pipelines further increases, while the chance of getting pollution from the Gaza coast decreases.

Site E

This site is similar to Site D, but located at a water depth of 22m, near the southern side of the coal terminal trestle, before the coal unloading pier. For this case the attributes are the same as for Site D, the intake head can be elevated also to about 10 m above the bottom, leaving yet at least 7m free vessel passage safety for the structure of the intake head. The increased water depth would further decrease the trapping of suspended sediments.

The drawbacks are similar to Site C, but the length of the pipelines further increases, while the chance of getting pollution from the Gaza coast further decreases. Coal pollution from the coal terminal is not expected, nor from the ships, as the current is flowing in a coast parallel pattern.

4. OUTCOME OF THE STUDY WORKS IN TASK 2

SSR prepared and submitted a list of data and lacking information for the completion of the study for the optimum siting of the desalination intake location at Katza port area and/or for the future steps in the process of tendering for the construction of the desalination pipeline and its intake head. These data and information are presented in the following:

4.1 Updated bathymetric and topographic information.

A bathymetric and topographic survey was ordered recently by the Israel Electric Company of the Rutenberg power station coastal area, and is or will be soon finished. It is recommended to contact IEC (Dr. Anat Glazer) and obtain/purchase a copy (preferably in digital AUTOCAD format) of the resulting map. It is recommended to request the survey in the New Israel Coordinates System if available. If it is available in the Old Israel Coordinates System, attention must be paid in further planning, as the formal planning documents are now requested in the NICS, and the conversion of coordinates is usually not straightforward and inaccurate. For an accurate conversion, it may be necessary to submit the data to the Survey of Israel and request accurate conversion (the usual the positioning accuracy provided is with an error of +/- 10m).

4.2 Aerial photography information

Aerial photography information has already been purchased according to our guidance from Ofek Aerial Photography and has been used in this ongoing study.

4.3 Information on sea bottom and sub-bottom structure

Information regarding the sea bottom at the contemplated site(s) for the intake head(s) and the sub-bottom along a corridor within which the pipeline(s) will be laid is necessary, to finalize the accurate location(s) of the intake heads and the pipelines paths. The needed information includes:

a. Side scan sonar imagery survey to detect presence of on-bottom features such as foreign bodies, protruding rocks above the sea bottom and the like.

b. Magnetometric survey to detect presence of buried metallic bodies (sunken ships, metal bars, etc.) which may endanger the pipelines and may impose change of laying path or prior removal.

c. Sub-bottom survey to find the thickness of the sand layer and the under layers structure such as shallow buried kurkar rocks, buried clay strata and the like. Such information is important for the optimum design of the type of laying of the pipelines (buried, on bottom, on sinkers), their sinkers and or protection against scouring and/or sea-bottom liquefaction, and for the optimum design of the foundation/anchoring of the intake heads structures.

d. Water jet pricking at a number of points along the path, for ground-true calibration and verification of the CHIRP acoustic measurements.

It is recommended that the 3 surveys will be conducted simultaneously, at intervals of 25m between the survey lines going along the pipelines path(s), with an additional number of survey lines perpendicular to the pipelines paths, at about 250m intervals.

The results should be presented by a bathymetric map, by isopach maps showing the sand thickness, soft clay thickness and total thickness of sediment above the kurkar rock or hard clay layer strata. Location of magnetic or foreign bodies targets on or below the sea bottom should be clearly described and marked on the bathymetric map. All the results should be presented in a report together with the data gathered, provided in digital format.

4.4 Bottom sand characterization

Samples of sediments at the water jet pricking sites and at the sites of the intake heads should be tested by granulometric analyses.

4.5 Soil strength properties

For proper design of the foundations at the intake heads, it is recommended to derive soil strength properties by taking cores using vibracore sampling to a depth of at least 6m in the bottom and/or using CPT measurements. This may be unnecessary if foundations will be based on piles driven into the sea bottom, but then achieved load strength testing is recommending. If such information will not be provided for the turn-key tender, higher bids may be expected, to cover for increased uncertainties. Existing information of soil properties along the coal unloading terminal and trestle are certainly available at the IEC, and depending on the final siting and data obtained, those might be sufficient for the tender.

4.6 Water quality and contents

Information regarding characterization of the sea-water quality (pollutants, pollution sources, installations and potential polluting sources), marine fauna and biota (including jelly-fish, fish, phytoplankton, etc.) is available partially from the IEC based on their experience with the operation of the Rutenberg power station water intake and with polluting prevention there. Additional information is available from IOLR. IOLR’s marine chemistry department can also provide sampling and analysis of sea water samples regarding its biological and chemical solid and dissolved contents and compare WHO, EPA and or other standards.

4.7 Data on the meteoceanographic environment

Based on our verbal information, a copy of the Environmental Impact Statement report submitted to the Ministry of Interior by the Eilat-Ashkenon Oil Pipeline Co. (Katza) regarding the construction of a Chemicals Terminal at Katza port with relevant meteoceanographic data at the coastal region of Katza port was obtained by IDE from Katza (Paz Engineering and

Management, 2001). The information provided in this report included additional statistical information regarding the wind, wave, current and sea-levels climate there. This information was used in the third task of the study.

Detailed information regarding the wave spectrum characteristics of an extreme storm condition which occurred during 20-21 February 2001 can, and is recommended to be obtained from IOLR. This storm was also concisely described by Zviely et al. (2001). According to the published data, it reached according to author’s assessment a deep water characteristic (significant) wave height of about 7.8 m off Haifa, corresponding to an average return period of about 35 years. The deep water characteristic wave height at Katza is estimated to have been slightly lower, about 7.5m, due to the fact that the storms have slightly larger fetches for more northerly sites along the coast. To the author’s estimate, it was the largest storm on the Israeli coast since 1965, if not since early 1950’s. Water quality at the Rutenberg cooling basin during this storm can probably be obtained from IEC, and wind conditions at Katza during that storm may be obtained from the Israel Meteorological Service.

5. OUTCOME OF THE STUDY WORKS IN TASK 3

Following the submission of the progress report for Task 1, and two meetings held with the client representatives, Eng. Avigdor Kaplan and Eng. Gad Haran, the client informed SSR that he selected the location of the intake heads at the three proposed sites B, C and D at the water depth contour lines of –15m water depth, of –17.5m water depth and of –20.0 m water depth for the study in Task 3. However, the client also decided that the intakes will be located on the northern side of the trestle of the coal unloading terminal of IEC.

According to the scope of Task 3, the study works conducted included the study of the local marine conditions at three sites selected by the client for the intake head, from the point of view of:

a. The determined local wave and current climate,

b. The local predominant and prevailing suspended load conditions,

c. The sea bottom bathymetry and sub-bottom (sand, kurkar, silt, clay),

d. The aspects of safety (to the intake head and pipeline and to navigation) and

e. Environmental impact.

5.1 Determination of wave and current climate at the 3 water depth contour lines

The local wave climate was derived by the author based on the data published by Rosen(1998) and the deep water was verified against that of Glozman (2000). The deep water wave climate was derived extrapolating for Ashkelon, based on the simultaneous deep water climates data published for Haifa, Hadera and Ashdod, during 5 sedimentological years (04/1994-03/1999), which are considered by the author as representative of the long-term average wave climate.

The deep water wave data were transformed via a wave refraction program written by the author into wave data climates at –15m water depth, at –17.5m water depth and at –20m water depth.

The outcome is presented in Tables 11-14 for deep water, -20 m, -17.5 m and –15.0 m correspondingly. Comparison of the wave height frequency distribution is shown for all waves in Figure No. 7 and for all waves heights with a total frequency less than 1% in Figure No. 8. In Figure No. 9 is presented the distribution of the peak wave periods. No directional distribution is presented since we are interested to determine the total (gross) sediment transports and concentrations.

Table No. 11 - KATZA DEEP WATER WAVE STATISTICS 04/94-03/99

Yearly frequency of characteristic wave height occurrence (Percentages), Sum over all directions

Tp(s)	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	
Hs interval [m]													Sum
0.0 - 0.2	0.91	0.68	0.59	0.17	0.09	0.12	0.02	0.02	0.01	0.01			2.63
0.2 - 0.4	2.97	3.91	2.80	2.45	0.83	0.45	0.14	0.09	0.03				13.68
0.4 - 0.6	2.19	5.44	5.52	6.00	2.46	0.75	0.27	0.10	0.03	0.01	0.01		22.78
0.6 - 0.8	0.91	3.51	4.57	5.72	4.48	1.06	0.30	0.15	0.13	0.03	0.01		20.86
0.8 - 1.0	0.15	1.58	2.72	2.83	4.37	1.45	0.19	0.21	0.12	0.02	0.01		13.63
1.0 - 1.2	0.01	0.52	1.63	1.65	2.54	2.14	0.22	0.08	0.13	0.08	0.03		9.03
1.2 - 1.4		0.16	0.78	0.86	1.12	1.89	0.30	0.09	0.13	0.02	0.01		5.36
1.4 - 1.6		0.07	0.28	0.57	0.57	1.62	0.45	0.11	0.06	0.01	0.01		3.75
1.6 - 1.8		0.03	0.15	0.32	0.40	0.75	0.43	0.10		0.01			2.20
1.8 - 2.0			0.07	0.17	0.27	0.46	0.33	0.07	0.02	0.01		0.01	1.40
2.0 - 2.2			0.04	0.15	0.28	0.44	0.27	0.10	0.06	0.02	0.01		1.36
2.2 - 2.4			0.05	0.05	0.21	0.26	0.21	0.08	0.04	0.03			0.92
2.4 - 2.6			0.02	0.04	0.09	0.14	0.22	0.10	0.05	0.01			0.67
2.6 - 2.8				0.02	0.04	0.09	0.09	0.13	0.04				0.41
2.8 - 3.0				0.01	0.01	0.06	0.08	0.12	0.06				0.33
3.0 - 3.2				0.01		0.04	0.03	0.09	0.03				0.21
3.2 - 3.4						0.05	0.05	0.06	0.04				0.21
3.4 - 3.6						0.03	0.06	0.04	0.04				0.17
3.6 - 3.8						0.01	0.02	0.09	0.06				0.18
3.8 - 4.0						0.01	0.03	0.02	0.04	0.01			0.09
4.0 - 4.2							0.02	0.02	0.02	0.01			0.07
4.2 - 4.4								0.01	0.01				0.02
4.4 - 4.6								0.01	0.01				0.02
4.6 - 4.8								0.01	0.02				0.02
4.8 - 5.0								0.01		0.01			0.02
5.0 - 5.2								0.01	0.01				0.02
Sum	7.14	15.90	19.22	21.00	17.75	11.80	3.73	1.87	1.19	0.28	0.10	0.01	100.00

Table No. 12 - KATZA WAVE STATISTICS 04/94-03/99 at –20m water depth contour

Yearly frequency of characteristic wave height occurrence (Percentages), Sum over all directions

Tp(s)	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	
Hs interval [m]													Sum
0.0 - 0.2	0.83	0.73	0.60	0.22	0.11	0.15	0.03	0.03	0.03	0.01			2.73
0.2 - 0.4	2.77	3.93	2.90	2.87	0.98	0.60	0.18	0.10	0.03				14.36
0.4 - 0.6	1.92	5.47	5.51	6.69	2.94	0.86	0.34	0.13	0.05	0.02	0.01		23.95
0.6 - 0.8	0.75	3.46	4.49	5.86	5.23	1.18	0.29	0.20	0.15	0.03	0.01		21.65
0.8 - 1.0	0.11	1.53	2.62	2.72	4.13	2.05	0.21	0.14	0.14	0.03	0.02		13.72
1.0 - 1.2	0.01	0.48	1.48	1.65	2.08	2.19	0.26	0.11	0.15	0.08	0.02		8.50
1.2 - 1.4		0.14	0.72	0.88	0.84	1.90	0.44	0.10	0.08	0.02	0.01	0.01	5.14
1.4 - 1.6		0.07	0.26	0.53	0.51	1.13	0.50	0.12	0.01		0.01		3.14
1.6 - 1.8		0.02	0.13	0.27	0.36	0.55	0.38	0.08	0.02	0.01			1.83
1.8 - 2.0			0.06	0.19	0.28	0.48	0.28	0.10	0.06	0.01	0.01	0.01	1.48
2.0 - 2.2			0.04	0.08	0.24	0.29	0.23	0.08	0.04	0.03			1.03
2.2 - 2.4			0.04	0.04	0.11	0.14	0.23	0.10	0.07	0.01			0.74
2.4 - 2.6			0.01	0.05	0.04	0.11	0.11	0.20	0.04				0.55
2.6 - 2.8				0.01	0.01	0.05	0.05	0.07	0.05				0.25
2.8 - 3.0				0.01		0.07	0.04	0.09	0.04				0.25
3.0 - 3.2						0.03	0.05	0.05	0.04				0.17
3.2 - 3.4						0.01	0.06	0.10	0.06				0.22
3.4 - 3.6						0.01	0.03	0.02	0.05				0.11
3.6 - 3.8							0.01	0.02	0.03	0.01			0.07
3.8 - 4.0								0.01	0.01	0.01			0.03
4.0 - 4.2								0.01	0.02				0.03
4.2 - 4.4								0.01	0.01				0.02
4.4 - 4.6								0.01	0.01	0.01			0.02
Sum	6.38	15.80	18.90	22.10	17.90	11.80	3.74	1.88	1.19	0.28	0.10	0.01	100

Table No. 13 - KATZA WAVE STATISTICS 04/94-03/99 at –17.5m water depth contour

Yearly frequency of characteristic wave height occurrence (Percentages), Sum over all directions

Tp(s)	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	Sum
Hs interval [m]													
0.0 - 0.2	0.83	0.73	0.61	0.23	0.12	0.15	0.03	0.03	0.03	0.01			2.76
0.2 - 0.4	2.77	3.93	2.94	2.98	1.02	0.62	0.18	0.1	0.02				14.56
0.4 - 0.6	1.92	5.47	5.59	6.83	3.07	0.87	0.34	0.13	0.05	0.01	0.01		24.29
0.6 - 0.8	0.75	3.46	4.51	5.78	5.32	1.19	0.29	0.2	0.15	0.03	0.01		21.67
0.8 - 1.0	0.11	1.53	2.57	2.68	4.09	2.08	0.22	0.15	0.15	0.03	0.02		13.63
1.0 - 1.2	0.01	0.47	1.44	1.62	1.97	2.18	0.25	0.11	0.15	0.08	0.02		8.29
1.2 - 1.4		0.15	0.69	0.8	0.8	1.91	0.45	0.1	0.07	0.03	0.01	0.01	5
1.4 - 1.6		0.07	0.25	0.54	0.49	1.1	0.5	0.12	0.01		0.01		3.08
1.6 - 1.8		0.02	0.13	0.27	0.35	0.55	0.38	0.07	0.02	0.01			1.8
1.8 - 2.0			0.06	0.16	0.3	0.47	0.27	0.11	0.06	0.01	0.01	0.01	1.46
2.0 - 2.2			0.04	0.08	0.22	0.28	0.23	0.08	0.04	0.03			1
2.2 - 2.4			0.04	0.03	0.08	0.13	0.24	0.11	0.06	0.02			0.7
2.4 - 2.6			0.01	0.04	0.04	0.11	0.11	0.18	0.05				0.54
2.6 - 2.8				0.01	0.01	0.05	0.05	0.09	0.06				0.25
2.8 - 3.0				0.01		0.07	0.05	0.09	0.04				0.25
3.0 - 3.2						0.03	0.06	0.05	0.04				0.18
3.2 - 3.4						0.01	0.05	0.09	0.05				0.2
3.4 - 3.6						0.01	0.03	0.03	0.06				0.13
3.6 - 3.8							0.01	0.02	0.03	0.01			0.07
3.8 - 4.0								0.01	0.01	0.01			0.03
4.0 - 4.2								0.01	0.01				0.02
4.2 - 4.4								0.01	0.02				0.02
4.4 - 4.6								0.01		0.01			0.02
4.6 - 4.8									0.01				0.01
Sum	6.38	15.8	18.9	22.1	17.9	11.8	3.74	1.88	1.19	0.28	0.1	0.01	100

Table No. 14 - KATZA WAVE STATISTICS 04/94-03/99 at –15.0 m water depth contour

Yearly frequency of characteristic wave height occurrence (Percentages), Sum over all directions

Tp(s)	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	
Hs interval [m]													Sum
0.0 - 0.2	0.83	0.73	0.63	0.24	0.12	0.15	0.03	0.03	0.03	0.01			2.80
0.2 - 0.4	2.77	3.94	3.11	3.14	1.05	0.63	0.18	0.09	0.02				14.93
0.4 - 0.6	1.92	5.51	5.59	6.98	3.17	0.88	0.34	0.13	0.04	0.01	0.01		24.59
0.6 - 0.8	0.75	3.45	4.47	5.66	5.39	1.20	0.29	0.20	0.15	0.03	0.01		21.60
0.8 - 1.0	0.11	1.52	2.56	2.66	4.05	2.12	0.21	0.15	0.15	0.03	0.02		13.56
1.0 - 1.2	0.01	0.46	1.38	1.53	1.84	2.15	0.26	0.11	0.14	0.08	0.03		7.99
1.2 - 1.4		0.15	0.63	0.75	0.79	1.90	0.43	0.09	0.09	0.03	0.01	0.01	4.86
1.4 - 1.6		0.06	0.22	0.54	0.48	1.10	0.49	0.13	0.02		0.01		3.05
1.6 - 1.8		0.02	0.13	0.26	0.35	0.55	0.39	0.06	0.01	0.01			1.78
1.8 - 2.0			0.06	0.14	0.31	0.47	0.26	0.11	0.06	0.01	0.01	0.01	1.43
2.0 - 2.2			0.04	0.07	0.21	0.26	0.24	0.08	0.03	0.03	0.01		0.97
2.2 - 2.4			0.03	0.04	0.06	0.13	0.23	0.10	0.06	0.02			0.67
2.4 - 2.6				0.03	0.04	0.11	0.12	0.16	0.06				0.51
2.6 - 2.8				0.01	0.01	0.04	0.05	0.12	0.05				0.28
2.8 - 3.0				0.01		0.07	0.04	0.08	0.04				0.25
3.0 - 3.2						0.02	0.06	0.06	0.05				0.19
3.2 - 3.4						0.01	0.05	0.07	0.04				0.18
3.4 - 3.6						0.01	0.04	0.05	0.06				0.16
3.6 - 3.8							0.01	0.02	0.03	0.01			0.07
3.8 - 4.0								0.01	0.02	0.01			0.04
4.0 - 4.2								0.01	0.01				0.02
4.2 - 4.4								0.01	0.02				0.03
4.4 - 4.6								0.01					0.01
4.6 - 4.8									0.01	0.01			0.02
Sum	6.38	15.80	18.90	22.10	17.90	11.80	3.74	1.88	1.19	0.28	0.10	0.01	100

In regards to the current climate at the site, there is limited information available. Current measurements were performed by the author during two years (1992-1994) approximately at the present location of the coal unloading terminal (at –27m contour line) for the IEC. Shallower current measurements in the contemplated area (-15m to –20m) are not available. However, based on the characteristics of the general circulation, use can be made of the near bottom current measurements performed by Oceana Research Ltd. at Ashdod in 15m water depth and in 24m water depth and since 2000 by IOLR at the deeper site in the whole water column.

The former results were reviewed by the author (Rosen, 1998) and the major outcome regards to the development of strong currents during storms due to wind induced water circulation, superposed on the wave induced current. As the wind veers during the strong westerly wave storms (with largest fetch) from the starting South-westerly direction at the beginning of the storm trough West at the peak of the storm and dies from Northwest at the storm decay stage, the wave induced current is strengthened by the wind induced current during the main part of the storm, and weakened by the opposing wind induced current during the decay stage. At Ashdod it was found that the strength of the current decreased at the deeper current site relative the shallower one. The new current data in the complete water column (with an ADCP RDI current meter) from Ashdod were not available for our interpretation, but they are available at the Israel Ports Authority.

Additional data however, were published on current measurements off Tel Baruch at –15m with an identical ADCP current meter (Rosentraub, 1999) in regards to the feasibility study of artificial islands on the central coast of Israel. They indicate that the flow in the water column is in general uniform, with decreasing speeds towards the bottom. At the contemplated water depths for the intake heads (-15m to –20m), the effect of thermal stratification in late spring was found to be insignificant.

There is no information about the presence of rip currents in the area, but such currents most probably occur. The importance of rip currents regards to the fact that they can transport sediments as bed load and suspended load offshore during heavy rain induced flood events. Such flood events in the region are not very frequent, and their frequency may also change due to the global warming induced climate change, presently underway. According to author's knowledge, such floods have occurred during February 1992, resulting in suspended very fine sediments reaching beyond the 2.2 km distance from the shoreline, painting the whole coastal area in a brownish water color for more than two weeks. Another major flood worth mentioning occurred due to an extreme flooding event in February 1975 in the central Sinai El-Arish river drainage basin, covering an area of about 20,000 km^2 of practically most of the central and northern part of Sinai (Rosen, 1998). According to Klein (1994), the hydrograph records at Ruafa dam, some 50 km upstream from the mouth, the maximum discharge reached about 1,650 m^3/sec such that within the 100 hours duration of the flood wave, some 125,000,000 m3 of water were drained to the sea, and a huge delta developed at the mouth of El-Arish river. Klein estimated that a volume of about 500,000m^3 of sediments were deposited in the delta which formed as an arch into the sea, protruding some 500 m into the sea, and about the same width at the shoreline. Comparing aerial photographs, Klein reached the conclusion that most of the delta disappeared within just one year. However, according to his own data, one year after the flood event (February 1976), the waterline position retreated to about 250m, spreading in both directions along the coast. The mentioned sediments must have induced also significant very fine suspended sediments in the coastal waters off Sinai, which were transported towards the Israeli coast by the wave induced and general circulation.

Based on the above information, we may summarize that the currents in the contemplated depths are affected by the general circulation of relatively weak strength, flowing about 70% of the time northward parallel to the coast, and can reach relatively high speeds of about 100cm/s (2 knots) or even more during very high storm conditions.

5.2 *Determination of the sediment transport climate at –15m, -17.5m and –20m.*

To understand the sediment transport climate at the contemplated sites, assessment of the relative and absolute characteristics of the suspended sediments at these sites was carried out. The study was based on the prevailing yearly average conditions as well as for a number of extreme characteristic conditions, using sediment transport numerical models developed in the Netherlands at Delft and Utrecht Universities as well as Coastal Engineering numerical and mathematical models developed by the US Corps of Engineers Waterways Experiment Station and sedimentological data selected by the author based on our experience and knowledge.

A lacking important parameter was the information about the actual local grain analysis distributions, which were not yet available. To overcome this, we have used general published data, as well as more detailed studies conducted off Ashdod coast. Comparing a detailed study conducted by LCHF (1957) on the coast of Ashdod for the coastal sector south to the site of the present Ashdod port, with the results of Birnbaum (1996) and those of Golik (1997), we found that the mean sand diameter size(D_{50}) at that coast remained constant over some 40 years. At the sector between –15m water depth and –20m water depth, the D_{50} was found of almost constant size, about 120 microns. Since the site at Ashkelon is considered to be very similar to that of the coast south to Ashdod port and the sediment granulometric distributions too, a slightly coarser sand mean size with D_{50} value of 125 microns has been assumed for the contemplated sites for the intake, and a D_{90} value of 300 microns (D_{90} representing the grain size diameter of the 90% biggest sand grains). A more refined assessment with fractions of the sand could not be conducted at this stage due to the lack of in situ data.

Using these sediment data assumed, sensitivity graphs indicating the total local sediment transport as function of wave and current parameters at –15m, at –17.5m and at –20m depth contour lines were computed and are presented in Figures 10 to 23. They show the dependence of the total sediment transport as function of the local significant wave height, peak wave period and average current speed. These show very clear that the deeper the intake location, the smaller the local sediment transport, of which the suspended transport contributes about 70 to 90%. They also show that with stronger currents, such as during wave storms with associated strong winds, the sediment transport increases significantly. It also increases in direct relationship with increasing wave height and wave period.

In addition, for 5 characteristic wave conditions representing the prevailing and predominant wave and current climate, detailed computations at the three locations were conducted using the TRANSPOR computer model developed by Van Rijn(1993), and improved by Grasmeijer and Van Rijn (2001). The outcome is presented for sediment concentration profiles in the water column for the 5 conditions in Figures 24 trough 28, and for sediment transport profiles in the water column in Figures 29 trough 33. They again indicate that the concentrations and sediment transport are smaller at –20m than at –17.5 m and much smaller than at –15m.

In addition in Figure 34 we reproduce some typical results obtained within REESAC project using satellite measurements of suspended matter on the Israeli coast (REESAC, 1999). It can be seen that during July – September significant amount of suspended matter arrived from the Nile delta and Sinai coast, decreasing in extent northwards along the Israeli coast and being locked closer to the shoreline. Even though this information is more of a qualitative than quantitative nature, it further strengthens the outcome that at the –20m site, smaller suspended matter will be encountered.

Another aspect considered is the minimum distance between two intake heads (this was not included in our original scope of works, but was requested to be added by the client at the time of the selection of the three sites). According to published literature, to prevent influence of one structure on the other from the point of view of the flow field, a minimum distance of 10 to 20 times the intake head diameter would be sufficient. However, we recommend that the intake heads will be placed one behind the other relative the wave direction of 285 degrees Azimuth (the orientation of the coal unloading terminal trestle), as this is the refracted approach wave direction of the highest sea states.

5.3 Foundation considerations regarding the sea bottom and sub-bottom

The selection of the optimum site for the water desalination intake heads must be finalized based on the local sea bottom and sub-bottom characteristics. Since in situ information was not available for our assessment, we will try to give guidance for the aspects to be considered when these data will become available. A major factor of concern is the sub-bottom composition. If kurkar rock is found in the area, this would make a good site from the point of view of foundation. If not, care should be paid to prevent sand liquefaction occurrence during extreme storm events from damaging the foundation. This can be in the form of proper rock filter laying on the sea bottom, usage of geotextile filters or foundation on driven steel/concrete piles with anti-scouring protection.

Another aspect relevant from the point of view of sea bottom and sub-bottom properties would be the presence of protruding or shallow kurkar (cemented sand rock) in the path of the water intake pipelines to the intake heads. According to the general pattern in this coastal region, it is estimated that at least two rows of protruding or very shallow (at least during storms) kurkar ridges would be encountered at the range of contour lines –3m to –5m and at –10m to –12m. Dense sub-bottom mapping of the potential area should provide information for the final optimum location from the point of view of minimum kurkar rock dredging.

Another aspect to be considered is the elevation of the intake head above the sea bottom. From the point of view of wave forces, the deeper the intake head from the surface and the deeper the local water depth, the smaller the wave and current forces acting on the intake structure. On the other hand, the opposite is true regarding the expected amount of suspended sediments and their grain size. Assuming a cylindrical type of intake structure (for reduced forces on it), there are two basic types: a horizontal cylindric intake and a vertical cylindric intake. Of the two, the latter seems to be more advantageous, as it can enable easier maintenance cleaning of its screens. From this aspect, it may be that a site located below the edge of the coal unloading terminal trestle would enable to use a crane or pulley lift system for cleaning/exchanging of the intake head screens.

5.4 Safety aspects

The location of the intake heads on the northern side of the terminal has the apparent advantage of the easier pipeline laying operations as compared to the case in which the intakes would be on the southern side of the coal unloading terminal trestle, since the latter would require to pass the pipelines underneath the trestle structure between the trestle piles. Such operation can still be performed but only in very calm sea conditions. Assuming that the intake heads would be on the northern side of the trestle and in water depth between 17.5 to 20m, it is recommended to consider their protection against hazardous bulk carrier ship collision (those visiting the terminal have droughts between 12m at ballast to 18m fully loaded) by constructing two breasting dolphins. Although this is a very small risk of occurrence event, such protection may be adequate in view of the potential damage to the water desalination power plant operation.

5.5 Environmental impact aspects to be considered

The location of the intake head has to take into consideration the known occurrence of heavy pollution events of the water column by jelly fish, in particular in summer. To prevent its entrapment, very low intake specific discharge would be recommended, to enable them to go away from the intake. A possible means to assist this (used also by the IEC at its cooling water intakes) is to release air bubbles in the water column around the intake head.

Fouling of the intake head screens should be given great attention. The present experience with marine fouling at water intakes at the IEC cooling basin intakes should be used. One of the major apparent items is the painting of the intake screens with silicon antifouling paints, which prevent very much against such fouling, and do not apparently have any toxic effect. However, such paints are quite expensive, but on the other hand are of long life.

Another aspect to be considered is the bottom scouring in the wake of the intake heads due to vortex shedding. As mentioned previously such case occurred due to oil pipelines laid on the sea bottom and to the characteristic predominant wave direction in this coastal sector. To prevent the initialization of such scouring by the intake heads structures (their parts close to the sea bottom up to 2-3 m above it), it is recommended to place in the northward shadow of the intake head sea bottom scouring protection (rock filter/geotextile) up to some 10 m northward from the intake heads.

6. CONCLUSIONS AND RECOMMENDATIONS

The study of the optimum site location for the intake heads of the water desalination pipeline intake system indicated a number of potential sites, of which 3 where selected by the client for further assessment. These 3 sites were at the water depth contour lines –15m, -17.5m and –20.0m.

The outcome of the study shows the best site from the point of view of lesser suspended sediments and organic matter as the site at –20m depth, followed closely by that at –17.5m, and much less adequate the site located on the –15m. The same conclusion is true from the point of view of survivability due to wave and current forces.

It is recommended that the intake heads will be located aligned one behind the other along an orientation of Azimuth 285 degrees.

It is also recommended to select vertical cylindrical type of intake head, as this would enable easier screen cleaning or replacement maintenance operations.

The elevation of the intake heads should be placed higher than 5m above the sea bottom, and preferably more than 7m below sea surface

The hydraulic design of the intake should consider future sea level rise and minimization of intake specific discharge.

Proper anti-scouring of the sea bottom must be placed at the intake heads and in their northern shadow.

To enable to determine the optimum location for the intake heads, sub-bottom CHIRP survey is necessary to be carried out. Only then it will be possible to decide it the present candidate for optimum selection, the –20m water depth site sector is indeed the optimum one. The final selection must include also economical aspects into consideration, which presently were only qualitatively included via the design forces and relative amounts of suspended matter. It should also include other costs such as those of the pipelines laying and protection against scouring and sagging and of the maintenance related to cleaning of the screens and the cleanliness of the sea water.

Protection of the intake heads against ship collision should be seriously considered. A pair of mooring dolphins such as those built at Hadera and Ashkelon coal unloading terminals may provide an adequate means for such protection.

7. AKNOWLEDGEMENTS

We wish to thank OTIV Desalination Partnership for entrusting Sea-Shore-Rosen with the performance of this study. The discussions and constructive remarks of the client representatives Mess. A. Kaplan, G. Haran and T. Reid were held in a warm and friendly atmosphere and are hereby acknowledged.

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FIGURES

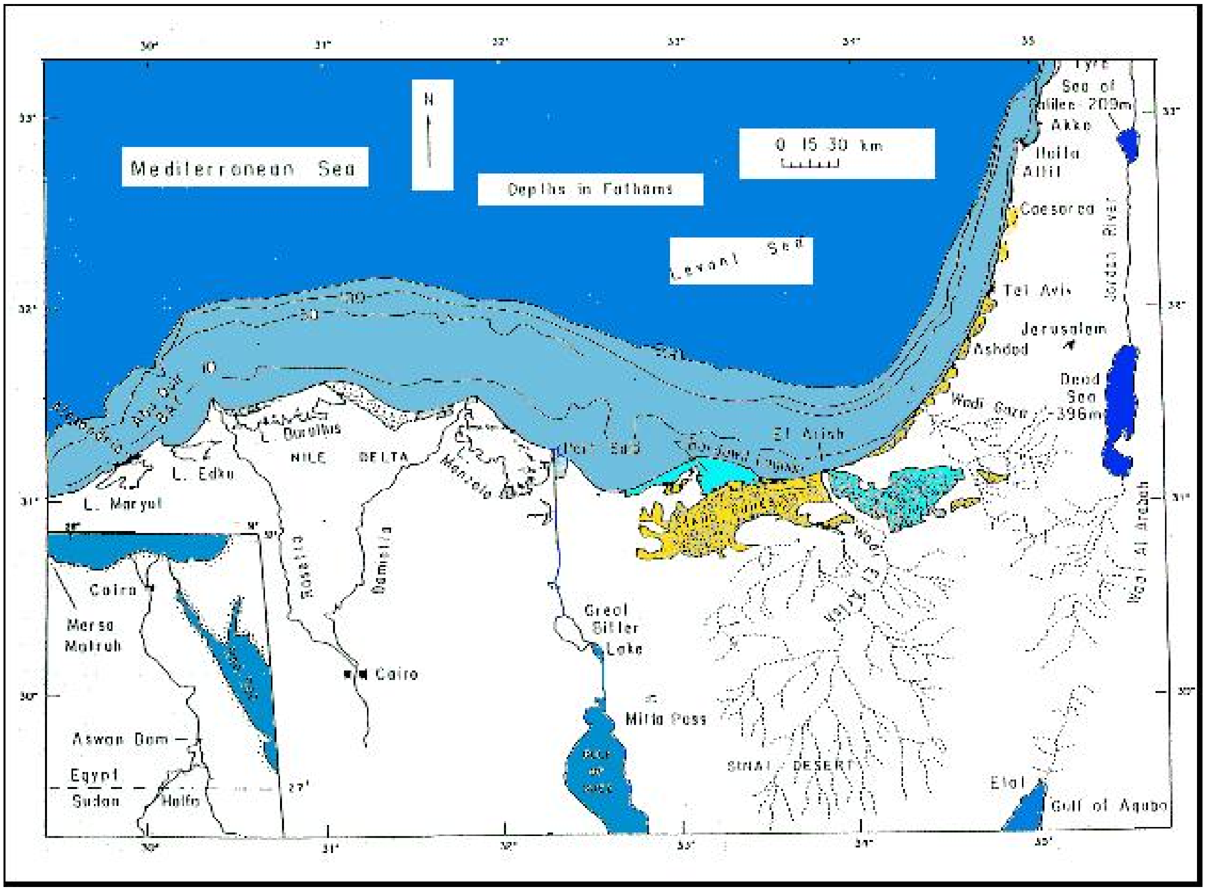


Figure 1 – General pattern of the Nile Littoral Cell

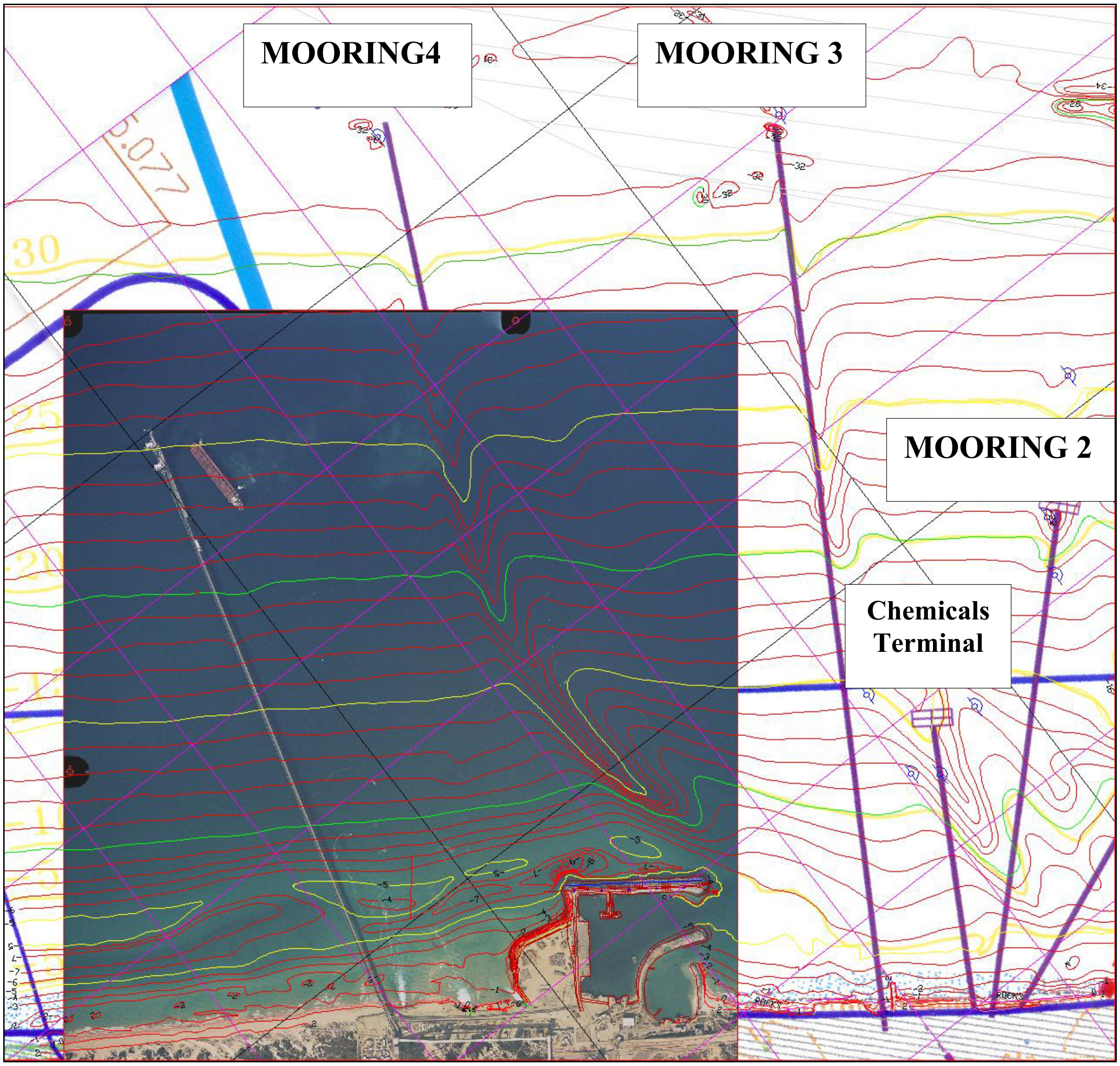


Figure 2 – General site description of KATZA coast

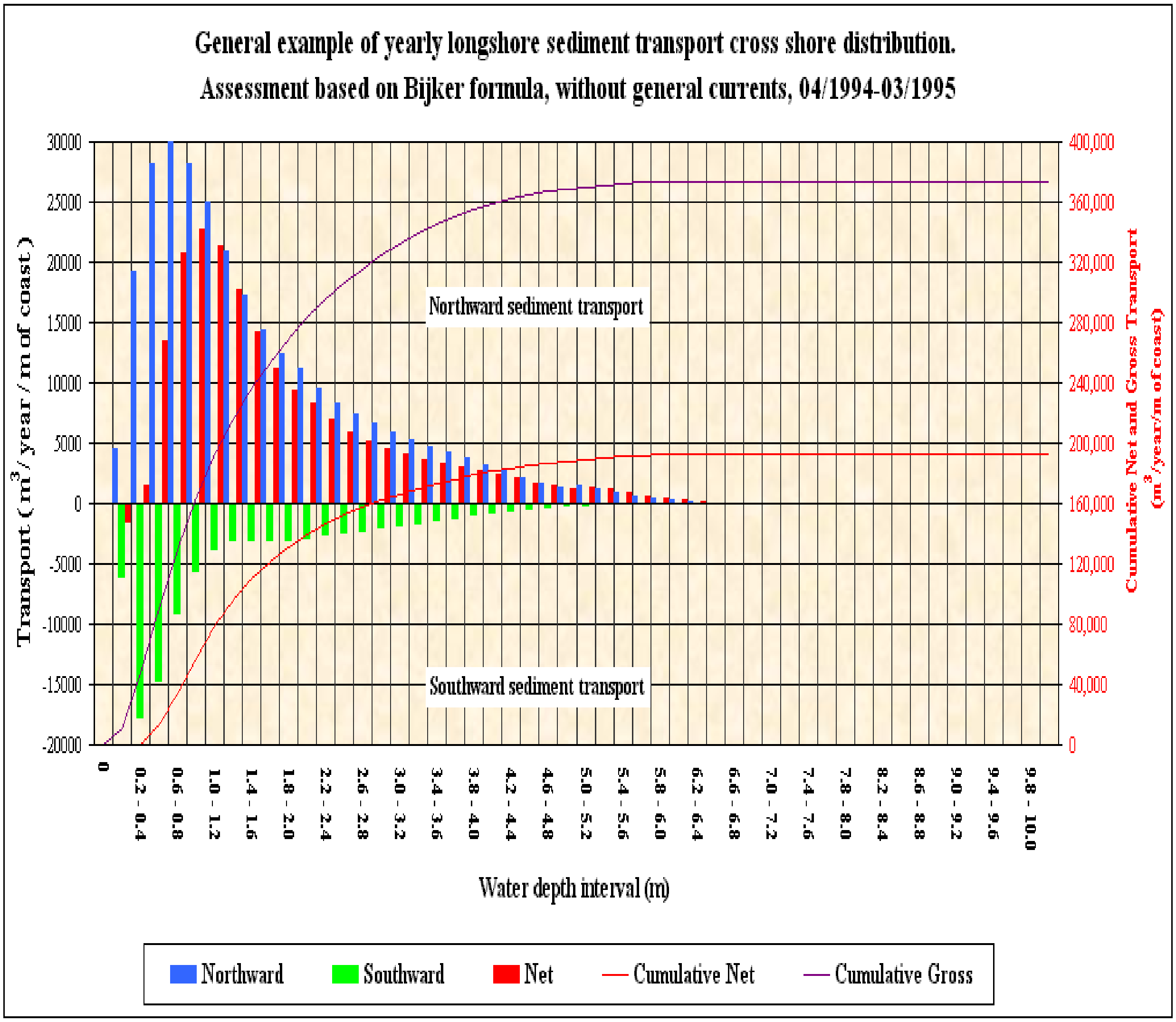

General example of yearly longshore sediment transport cross shore distribution.
Assessment based on Bijker formula, without general currents, 04/1994-03/1995

Figure 3a – Typical longshore current cross-shore profile

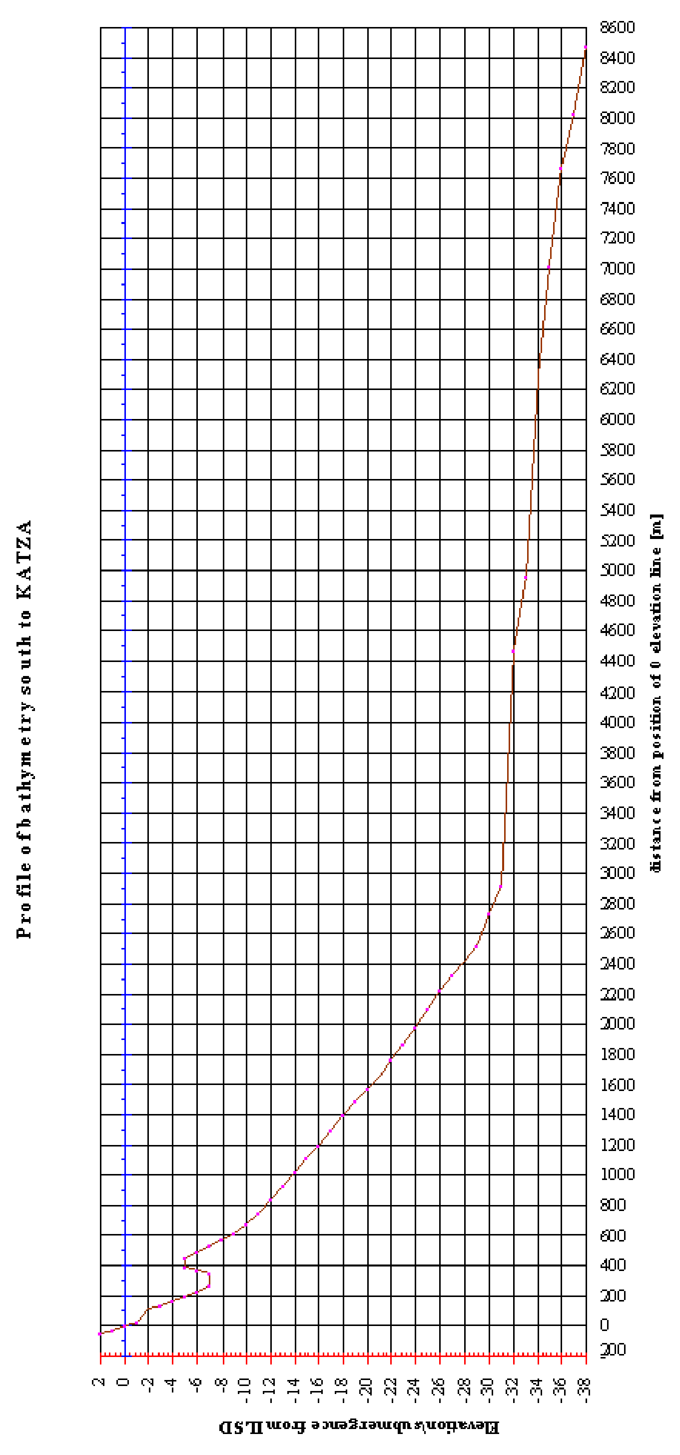


Figure 3b – Cross shore profile South to Rutenberg cooling basin

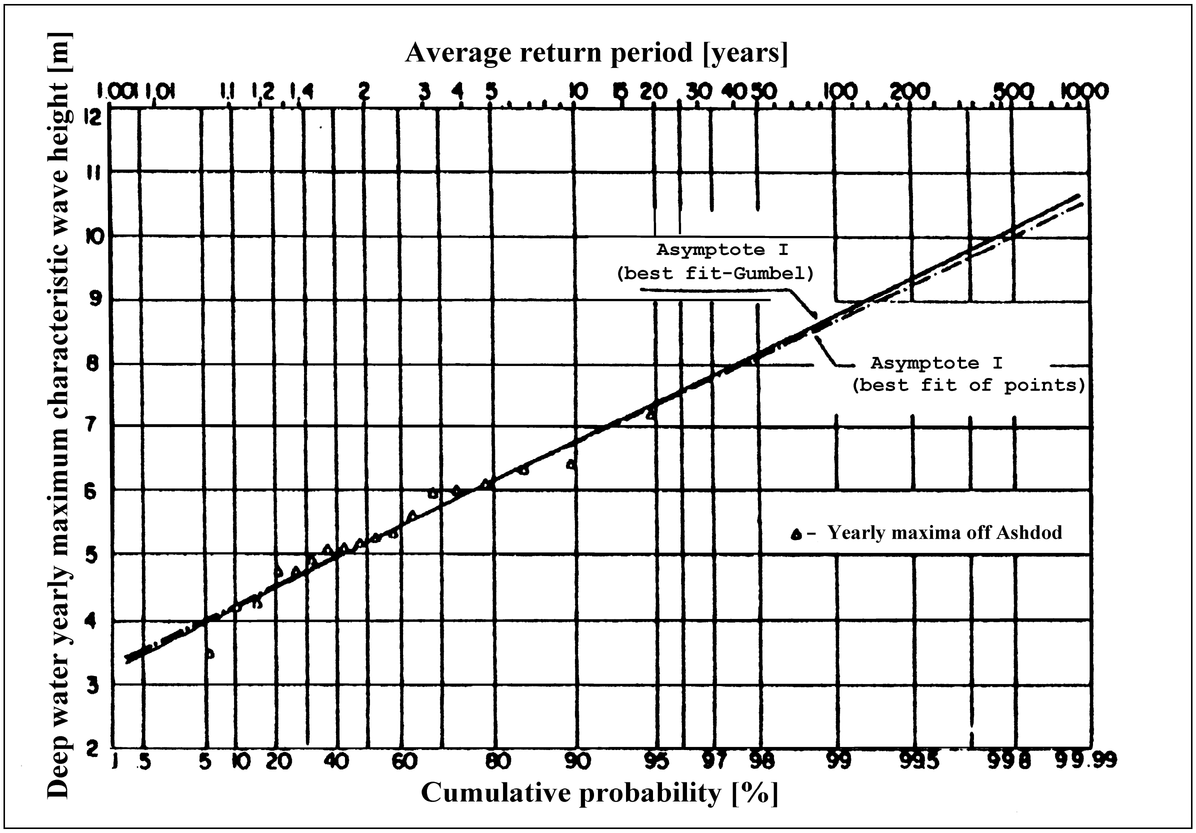


Figure 4 -Statistics of extreme sea states (from Rosen, 1998)

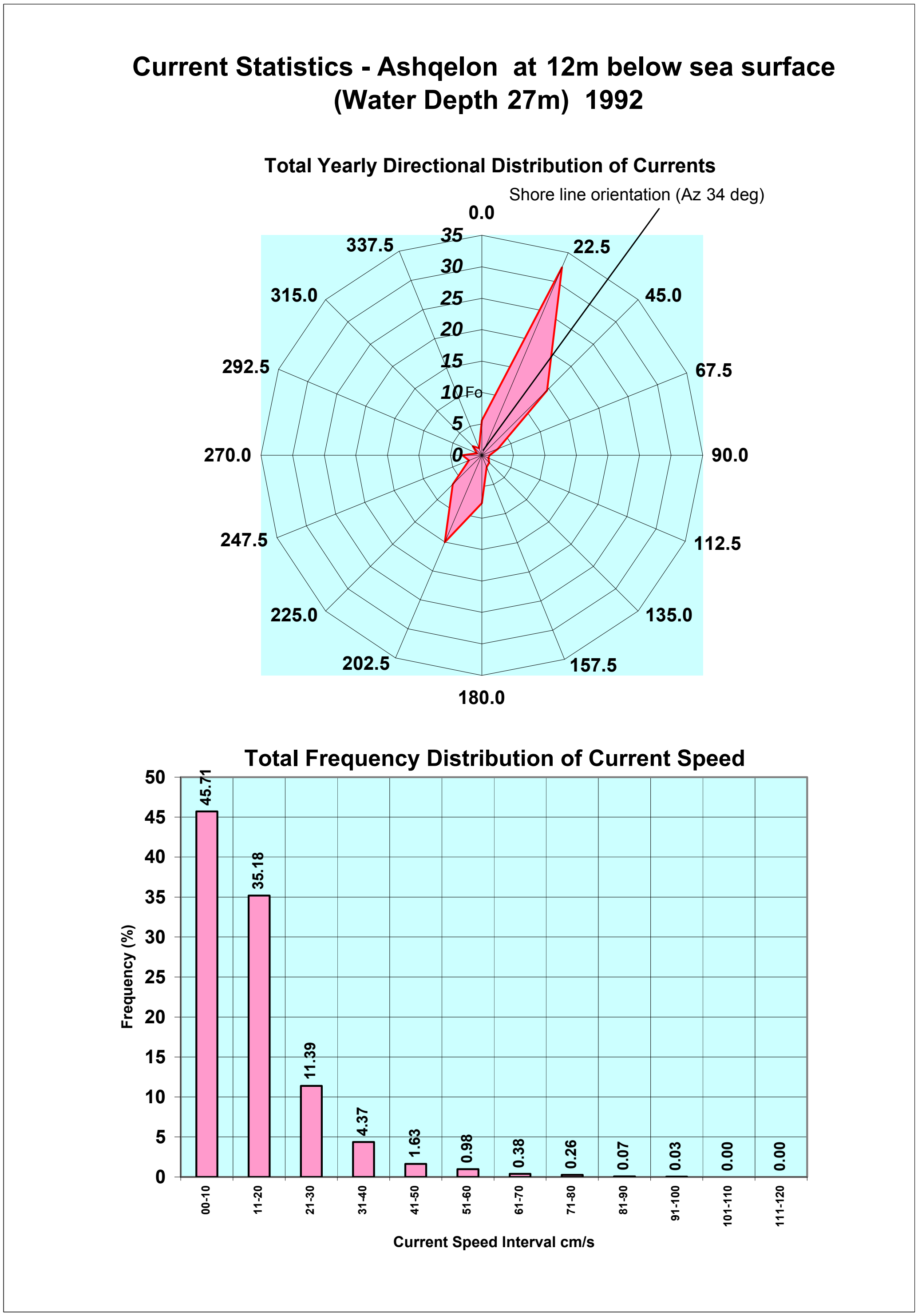


Figure 5 – General currents at KATZA (from Rosen, 1998)

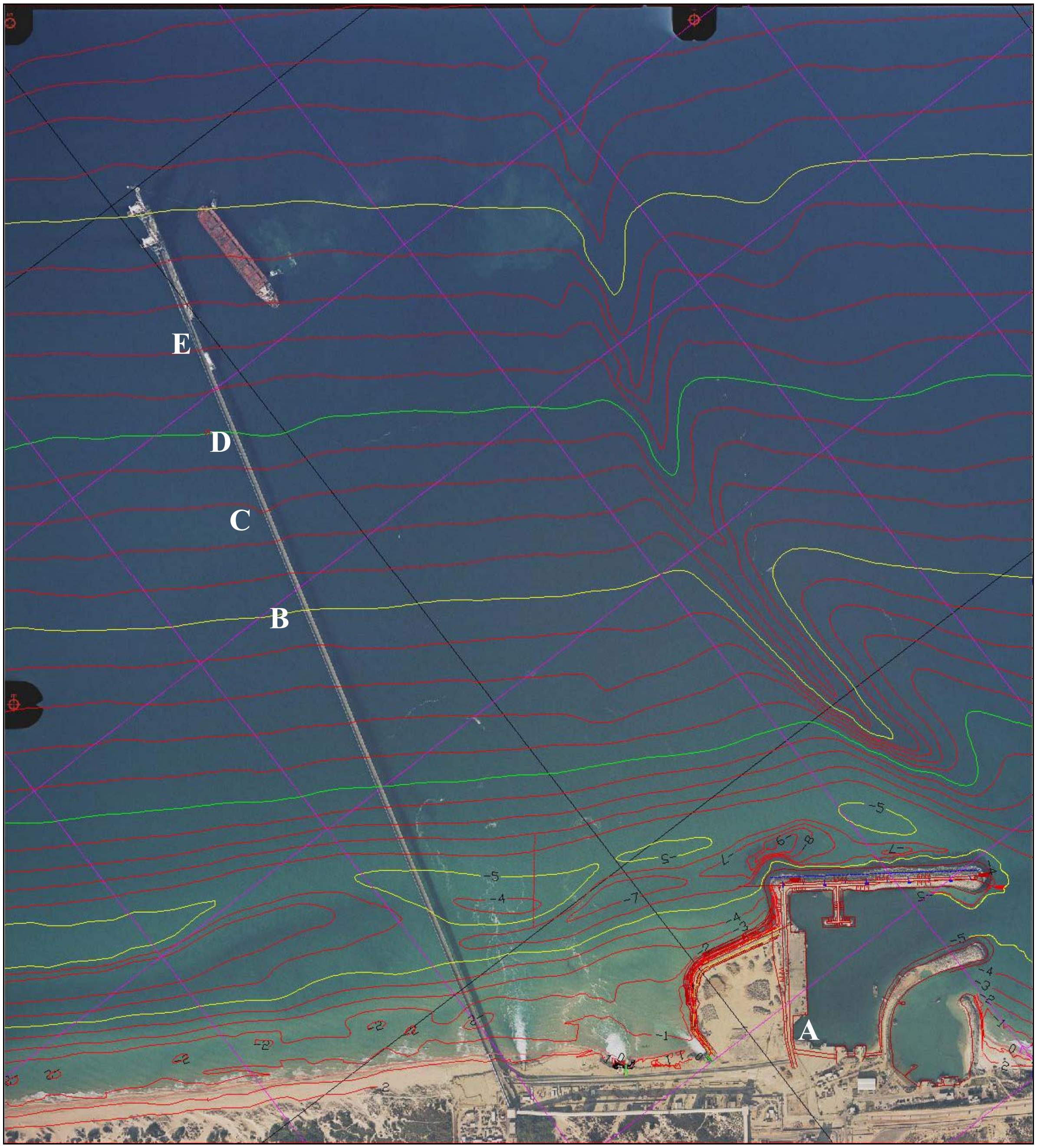


Figure 6 – Detailed location of the proposed sites for the intake head structure of the sea water desalination plant

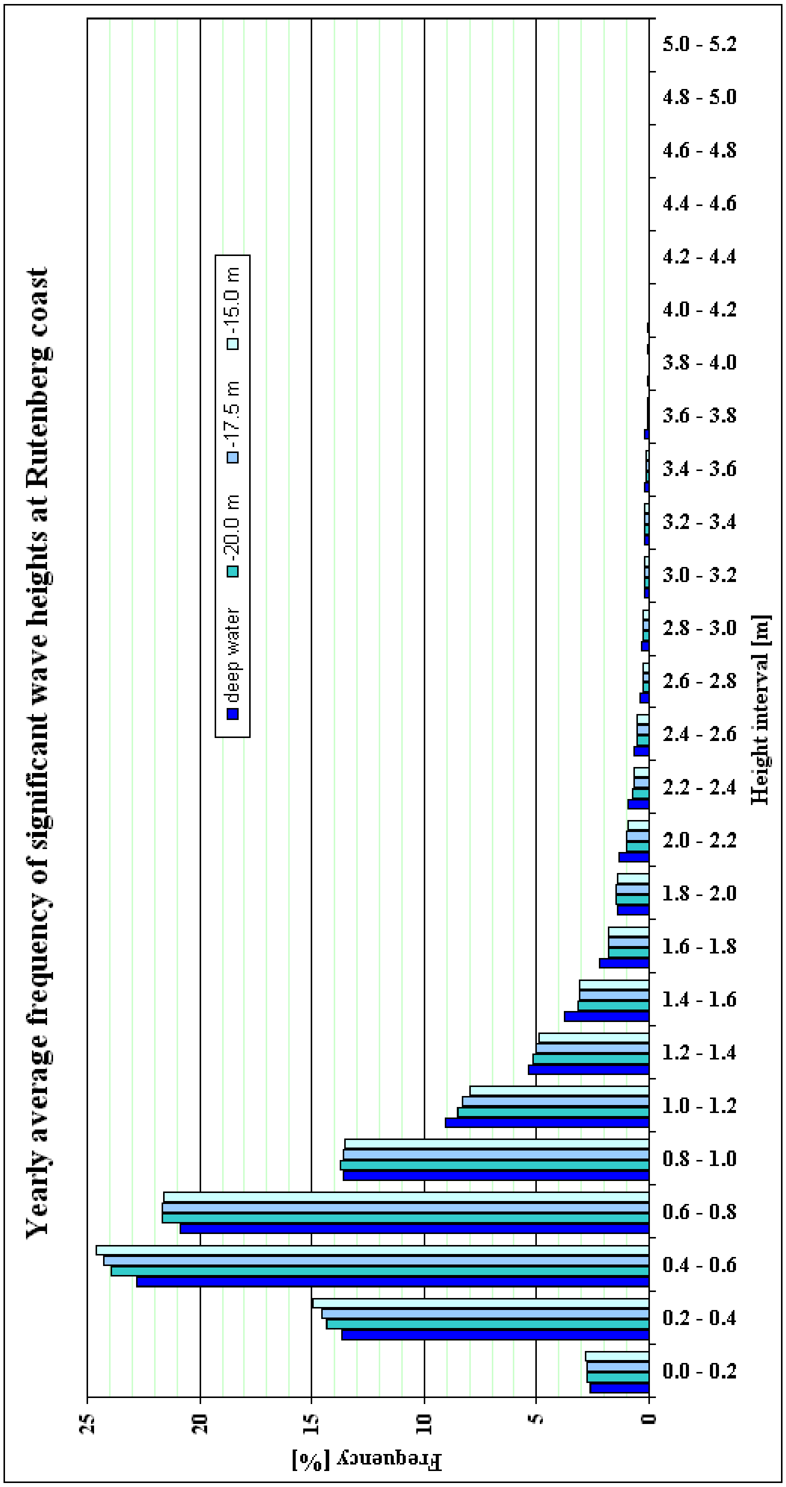

Yearly average frequency of significant wave heights at Rutenberg coast
■ deep water
■ -20.0 m
□ -17.5 m
□ -15.0 m
Frequency [%]
0
5
10
15
20
25
Height interval [m]
0.0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
1.0 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
1.8 - 2.0
2.0 - 2.2
2.2 - 2.4
2.4 - 2.6
2.6 - 2.8
2.8 - 3.0
3.0 - 3.2
3.2 - 3.4
3.4 - 3.6
3.6 - 3.8
3.8 - 4.0
4.0 - 4.2
4.2 - 4.4
4.4 - 4.6
4.6 - 4.8
4.8 - 5.0
5.0 - 5.2

Figure 7

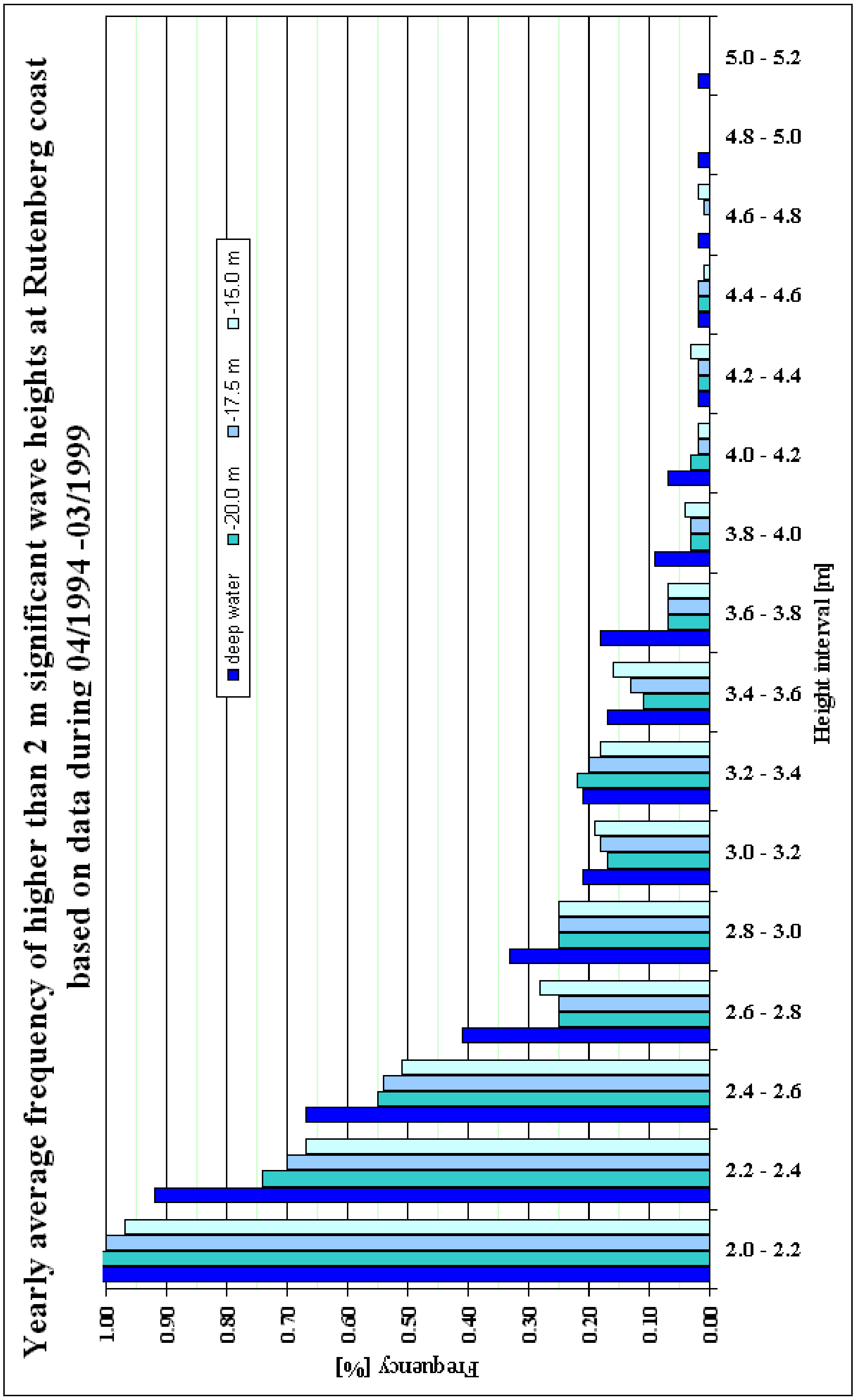

Yearly average frequency of higher than 2 m significant wave heights at Rutenberg coast
based on data during 04/1994 -03/1999
deep water
-20.0 m
-17.5 m
-15.0 m
Frequency [%]
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Height interval [m]
2.0 - 2.2
2.2 - 2.4
2.4 - 2.6
2.6 - 2.8
2.8 - 3.0
3.0 - 3.2
3.2 - 3.4
3.4 - 3.6
3.6 - 3.8
3.8 - 4.0
4.0 - 4.2
4.2 - 4.4
4.4 - 4.6
4.6 - 4.8
4.8 - 5.0
5.0 - 5.2

Figure 8

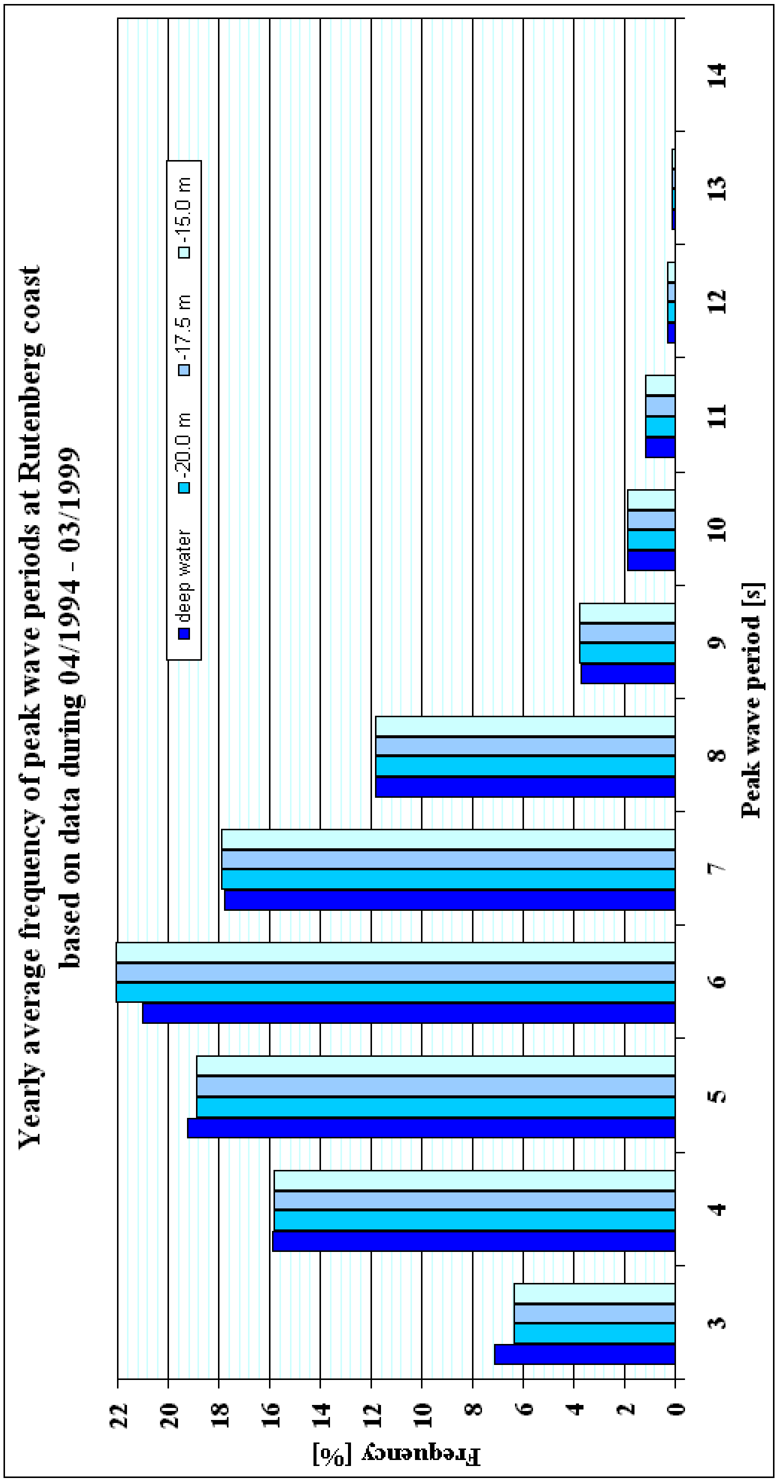

Yearly average frequency of peak wave periods at Rutenberg coast
based on data during 04/1994 - 03/1999
■ deep water
■ -20.0 m
■ -17.5 m
□ -15.0 m
Frequency [%]
0
2
4
6
8
10
12
14
16
18
20
22
Peak wave period [s]
3
4
5
6
7
8
9
10
11
12
13
14

Figure 9

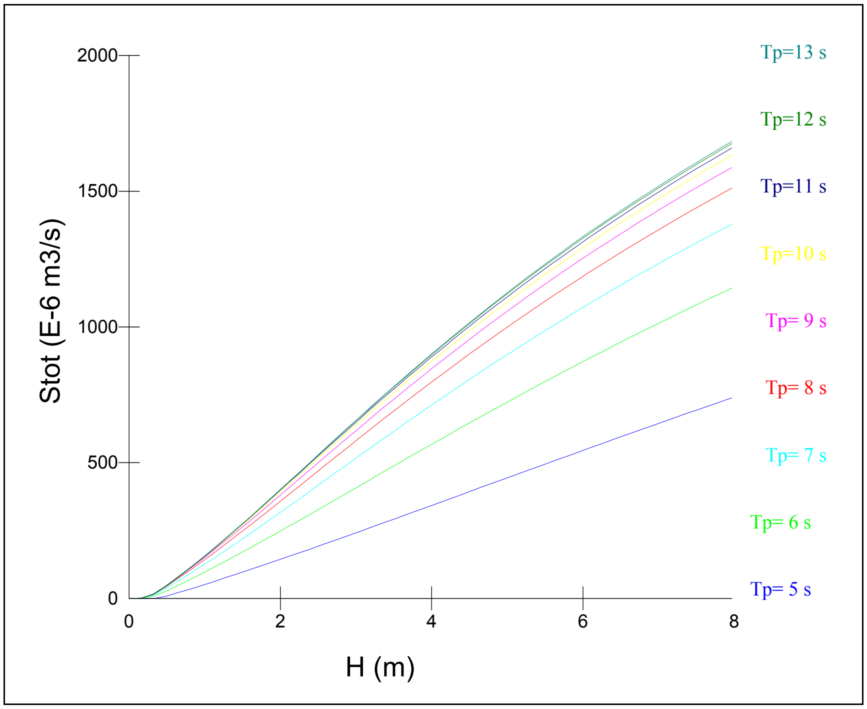


Figure 10 - Total local sediment transport as function of wave parameters at –15m depth contour line
(Current velocity 0.1m/s; d50=125microns, d90=300 microns; ripple height = 3cm)

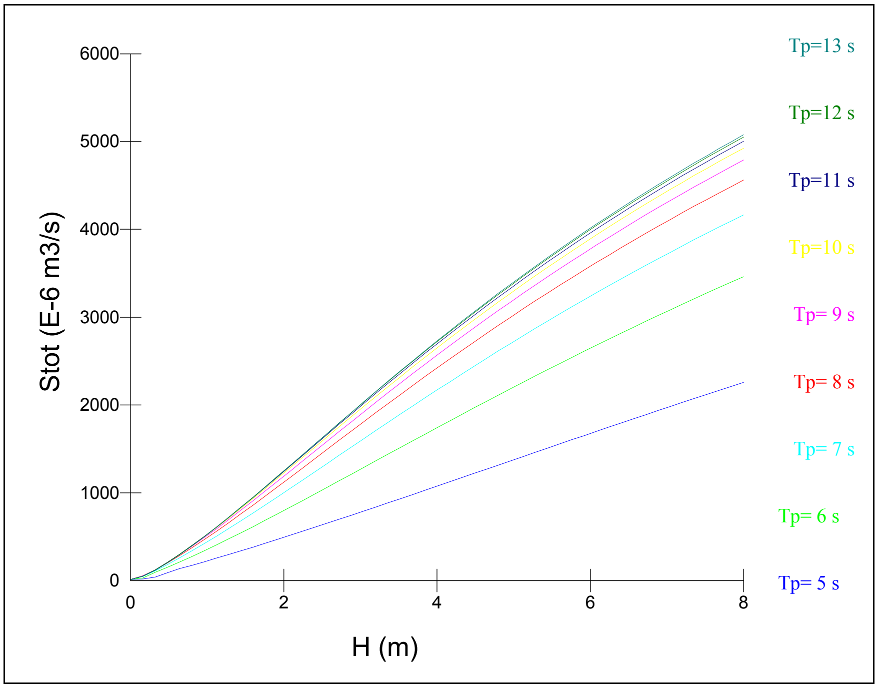


Figure 11 - Total local sediment transport as function of wave parameters at –15m depth contour line
(Current velocity 0.3 m/s; d50=125microns, d90=300 microns; ripple height = 3cm)

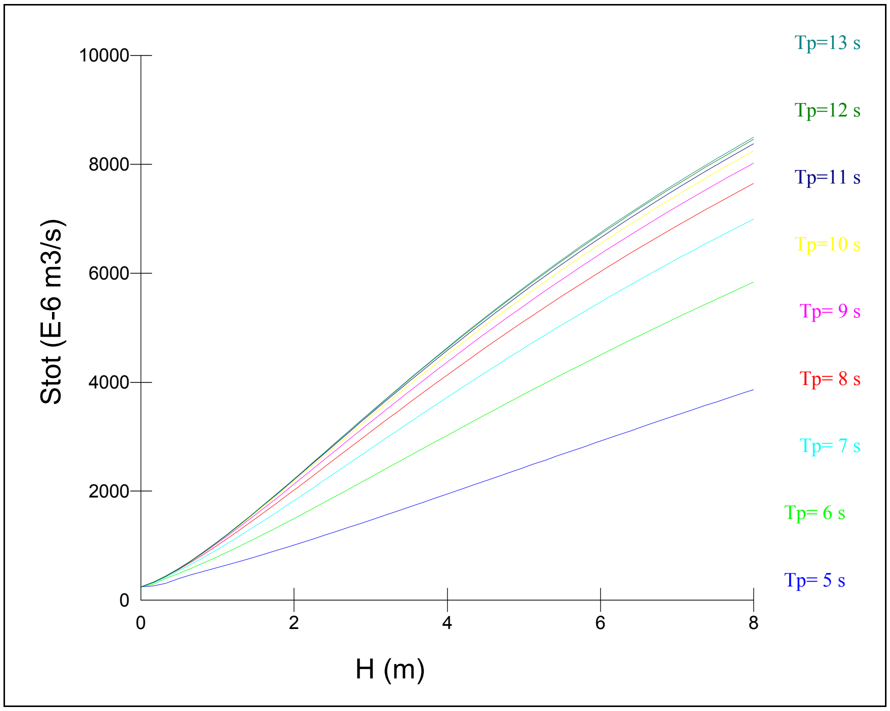


Figure 12 - Total local sediment transport as function of wave parameters at –15m depth contour line
(Current velocity 0.5 m/s; d50=125microns, d90=300 microns; ripple height = 3cm)

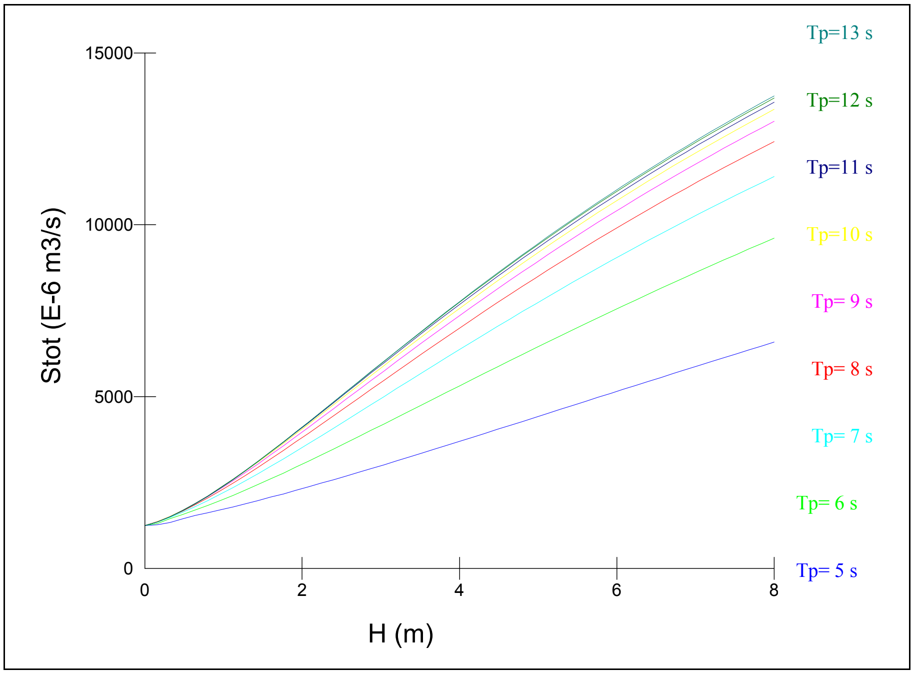


Figure 13 - Total local sediment transport as function of wave parameters at –15m depth contour line
(Current velocity 0.8 m/s; d50=125microns, d90=300 microns; ripple height = 3cm)

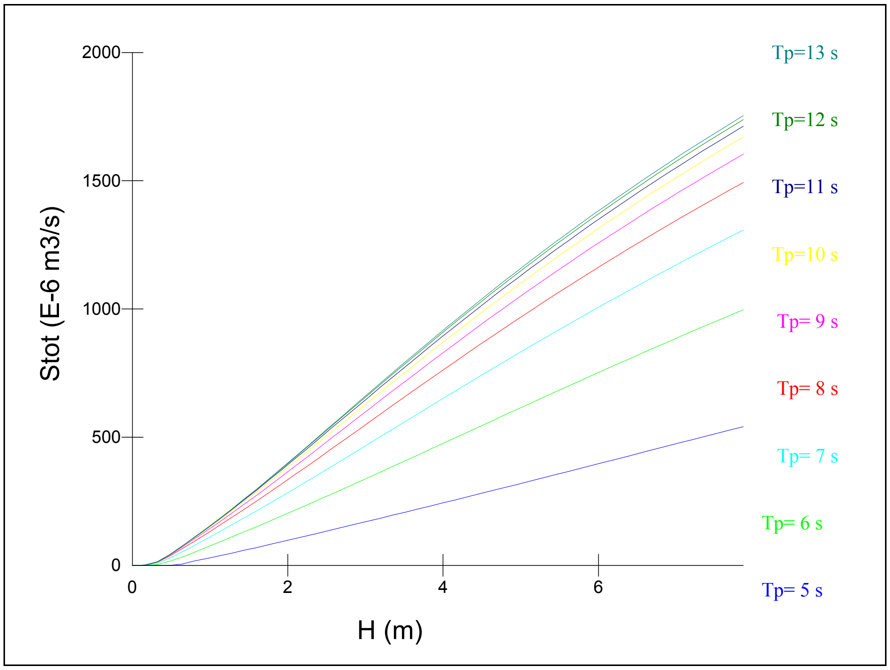


Figure 14 - Total local sediment transport as function of wave parameters at –17.5m depth contour line
(Current velocity 0.1 m/s; d50=125microns, d90=300 microns; ripple height = 3cm)

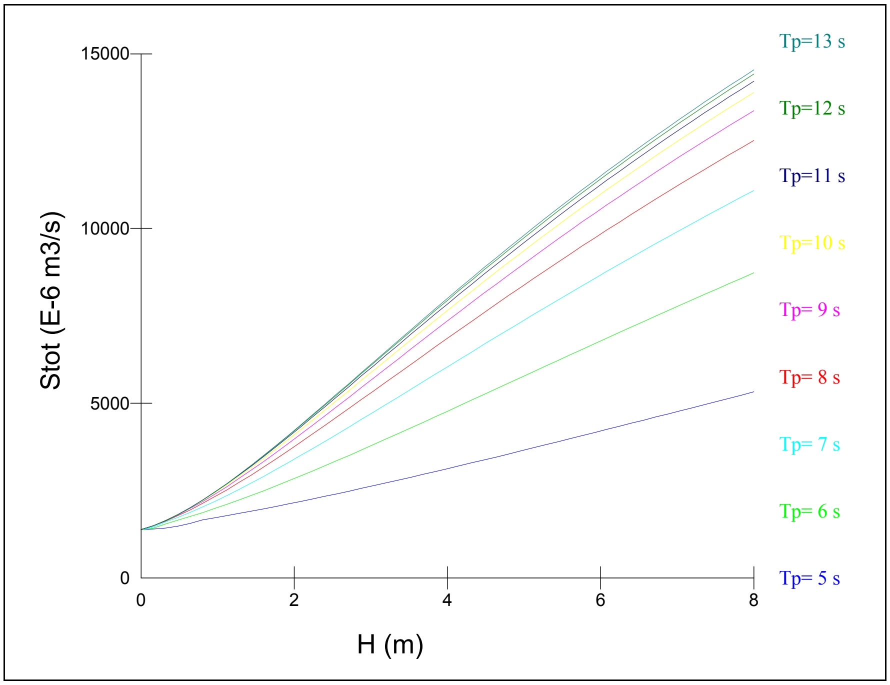


Figure 15 - Total local sediment transport as function of wave parameters at –17.5m depth contour line
(Current velocity 0.8 m/s; d50=125microns, d90=300 microns; ripple height = 3cm)

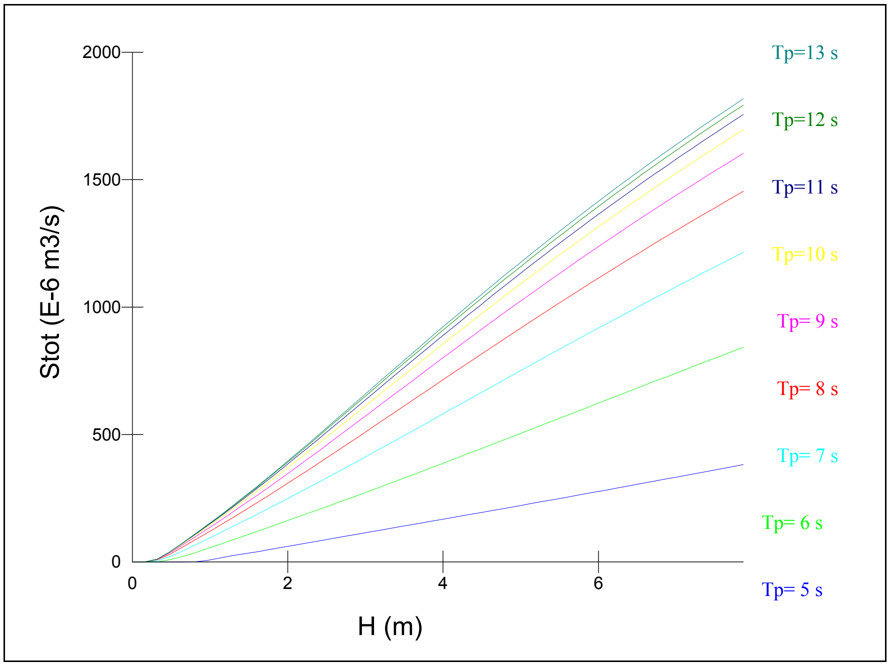


Figure 16 - Total local sediment transport as function of wave parameters at –20.0m depth contour line
(Current velocity 0.1 m/s; d50=125microns, d90=300 microns; ripple height = 3cm)

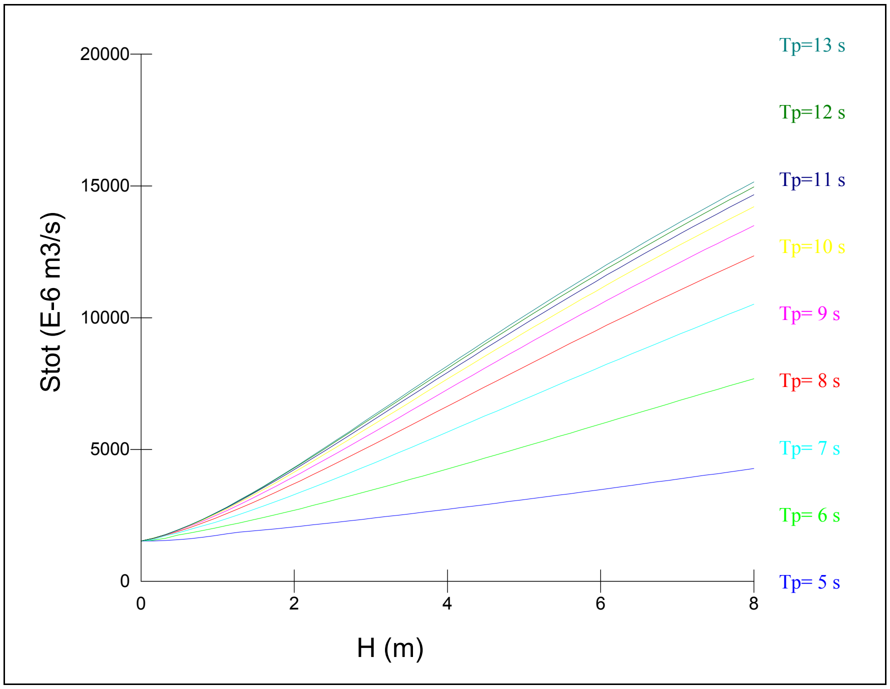


Figure 17 - Total local sediment transport as function of wave parameters at –20.0m depth contour line
(Current velocity 0.8 m/s; d50=125microns, d90=300 microns; ripple height = 3cm)

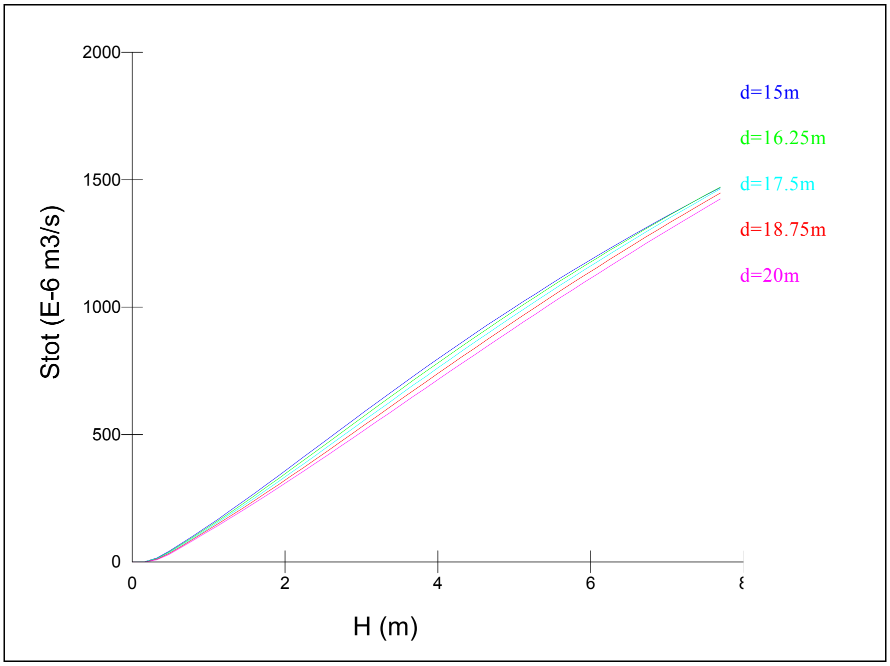


Figure 18 - Total local sediment transport as function of water depth and significant wave height
(Current velocity 0.1 m/s; d50=125microns, d90=300 microns; ripple height = 3cm; Tp=8s)

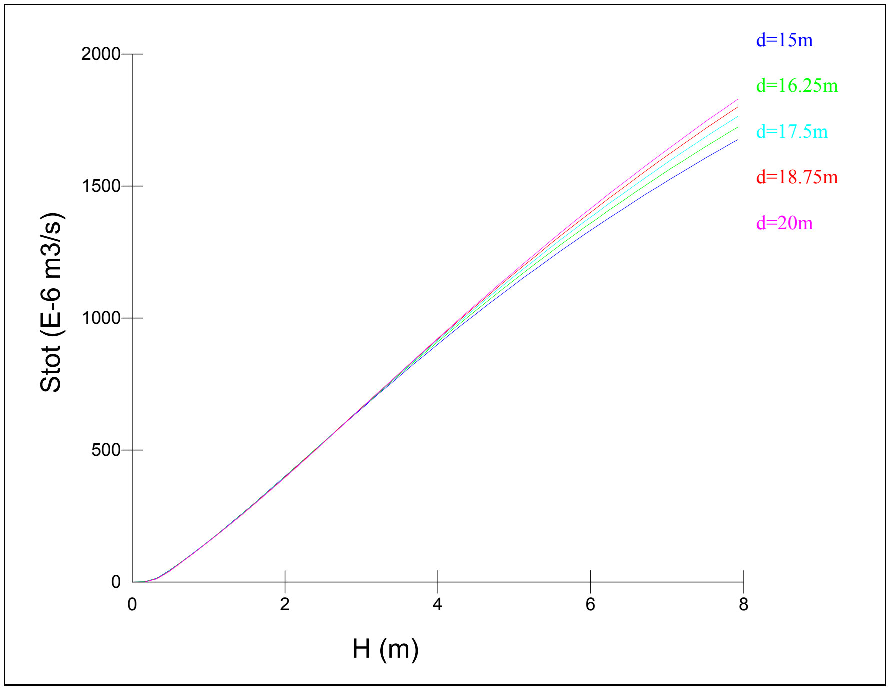


Figure 19 - Total local sediment transport as function of water depth and significant wave height
(Current velocity 0.1 m/s; d50=125microns, d90=300 microns; ripple height = 3cm; Tp=13s)

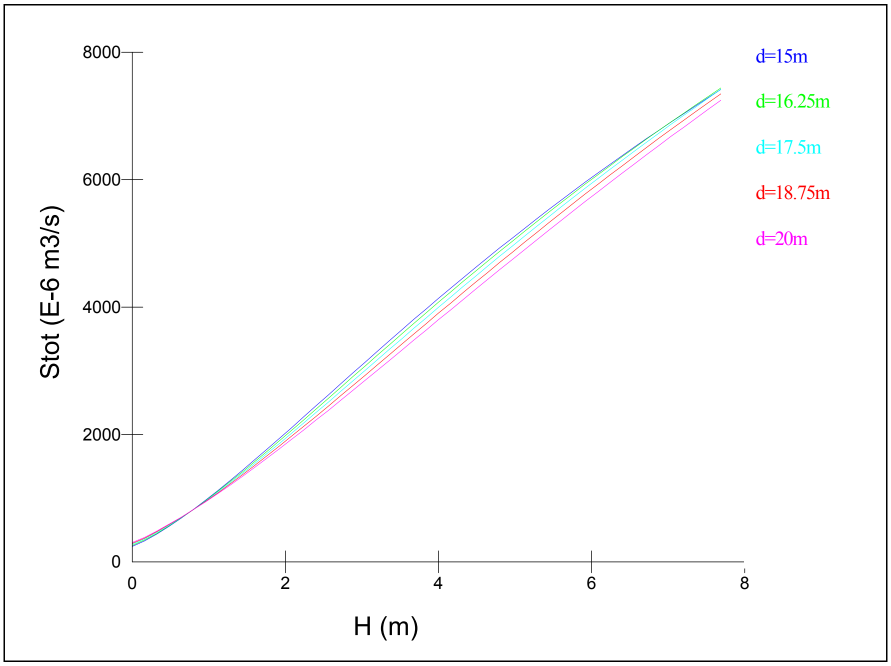


Figure 20 - Total local sediment transport as function of water depth and significant wave height
(Current velocity 0.5 m/s; d50=125microns, d90=300 microns; ripple height = 3cm; Tp=8s)

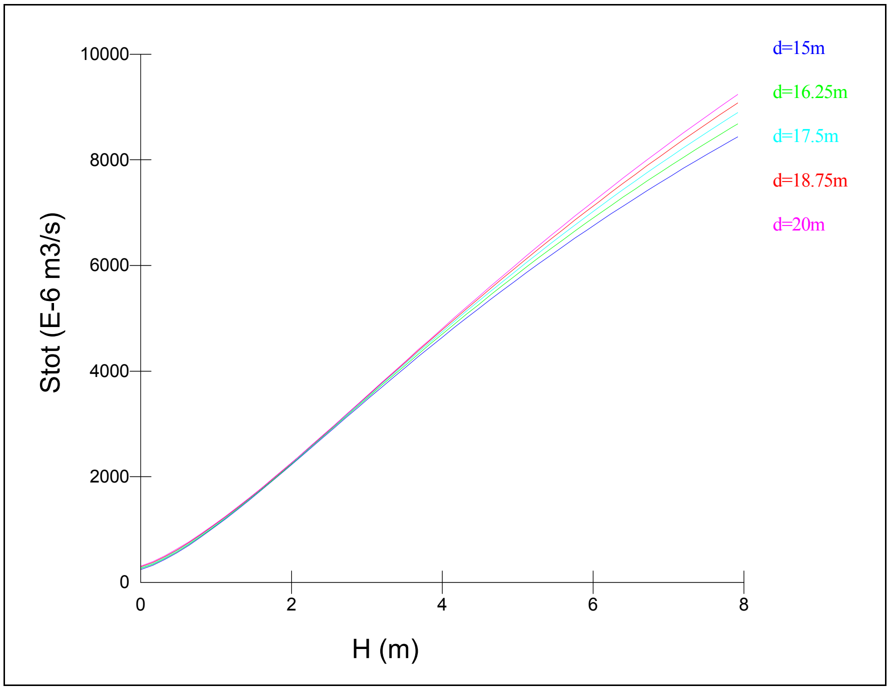


Figure 21 - Total local sediment transport as function of water depth and significant wave height
(Current velocity 0.5 m/s; d50=125microns, d90=300 microns; ripple height = 3cm; Tp=13s)

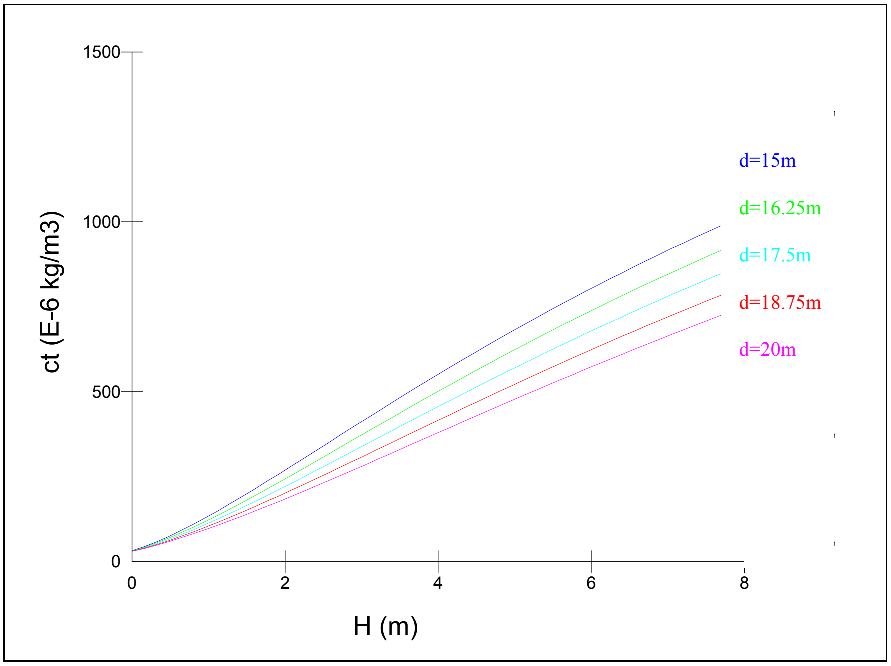


Figure 22 - Total local average sediment concentration vs depth contour and significant wave height
(Current velocity 0.5 m/s; d50=125microns, d90=300 microns; ripple height = 3cm; Tp=8s)

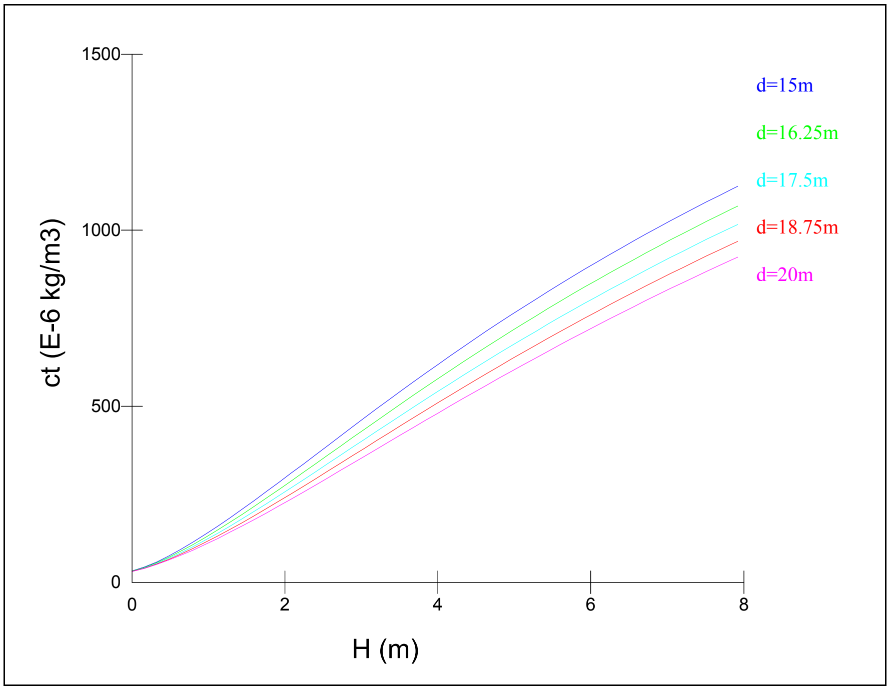


Figure 23 - Total local average sediment concentration vs depth contour and significant wave height
(Current velocity 0.5 m/s; d50=125microns, d90=300 microns; ripple height = 3cm; Tp=13s)

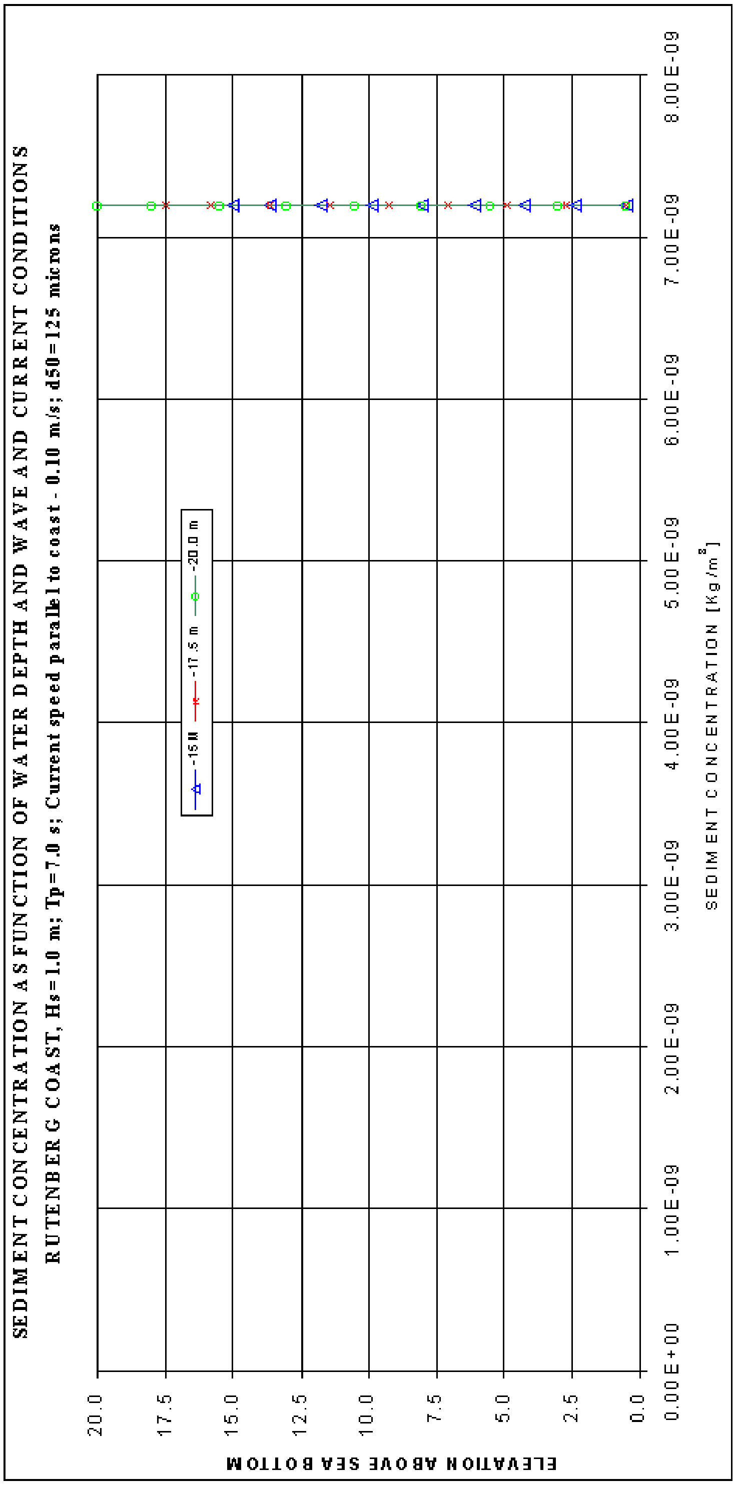

SEDIMENT CONCENTRATION AS FUNCTION OF WATER DEPTH AND WAVE AND CURRENT CONDITIONS
RUTENBERG COAST, Hs=1.0 m; Tp=7.0 s; Current speed parallel to coast - 0.10 m/s; d50=125 microns
-15 M
-17.5 m
-20.0 m
ELEVATION ABOVE SEA BOTTOM
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
SEDIMENT CONCENTRATION [Kg/m3]
0.00E+00
1.00E-09
2.00E-09
3.00E-09
4.00E-09
5.00E-09
6.00E-09
7.00E-09
8.00E-09

Figure No. 24

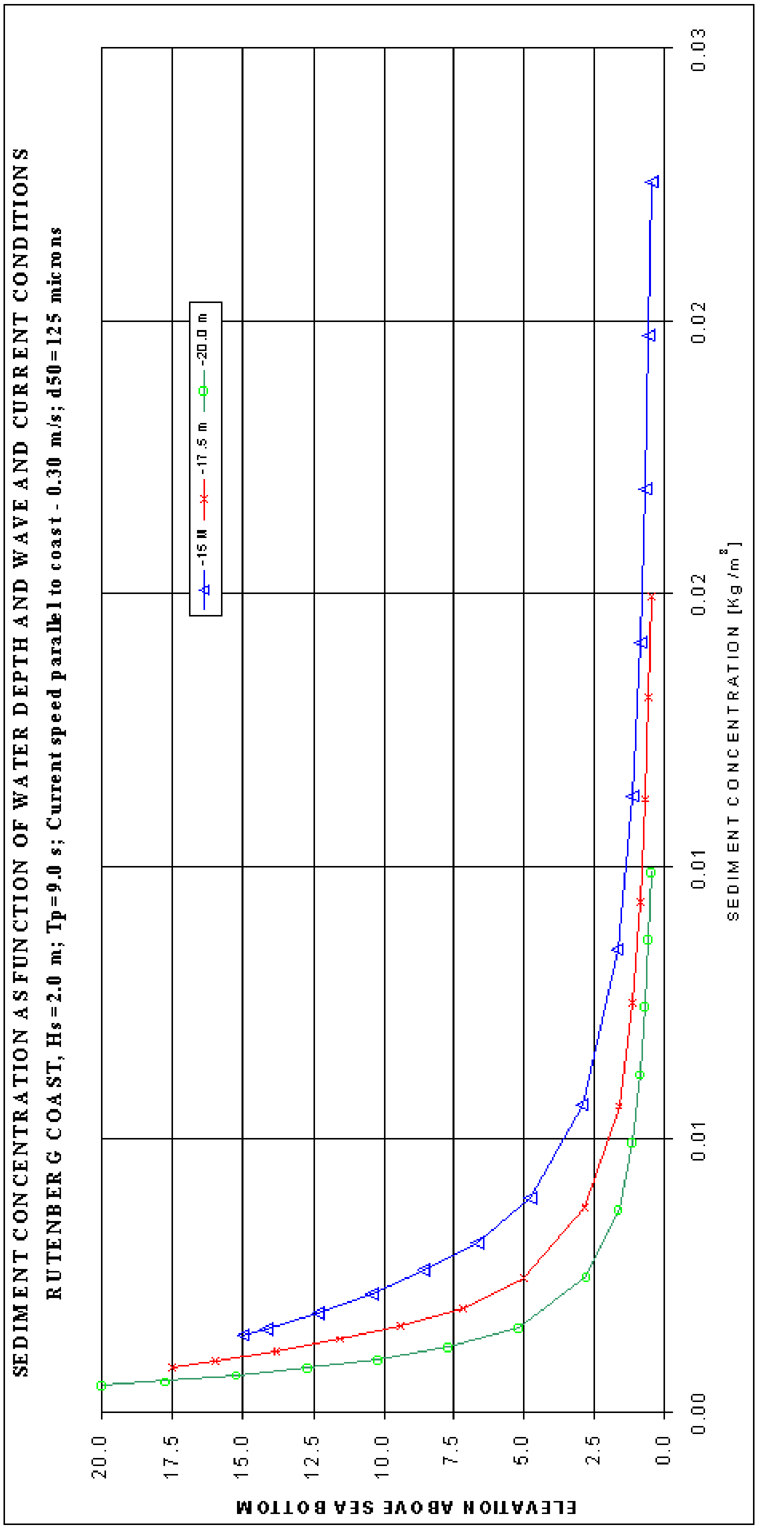

SEDIMENT CONCENTRATION AS FUNCTION OF WATER DEPTH AND WAVE AND CURRENT CONDITIONS
RUTENBERG COAST, Hs=2.0 m; Tp=9.0 s; Current speed parallel to coast - 0.30 m/s; d50=125 microns
-15 M
-17.5 m
-20.0 m
ELEVATION ABOVE SEA BOTTOM
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
0.00
0.01
0.01
0.02
0.02
0.03
SEDIMENT CONCENTRATION [Kg/m^3]

Figure No. 25

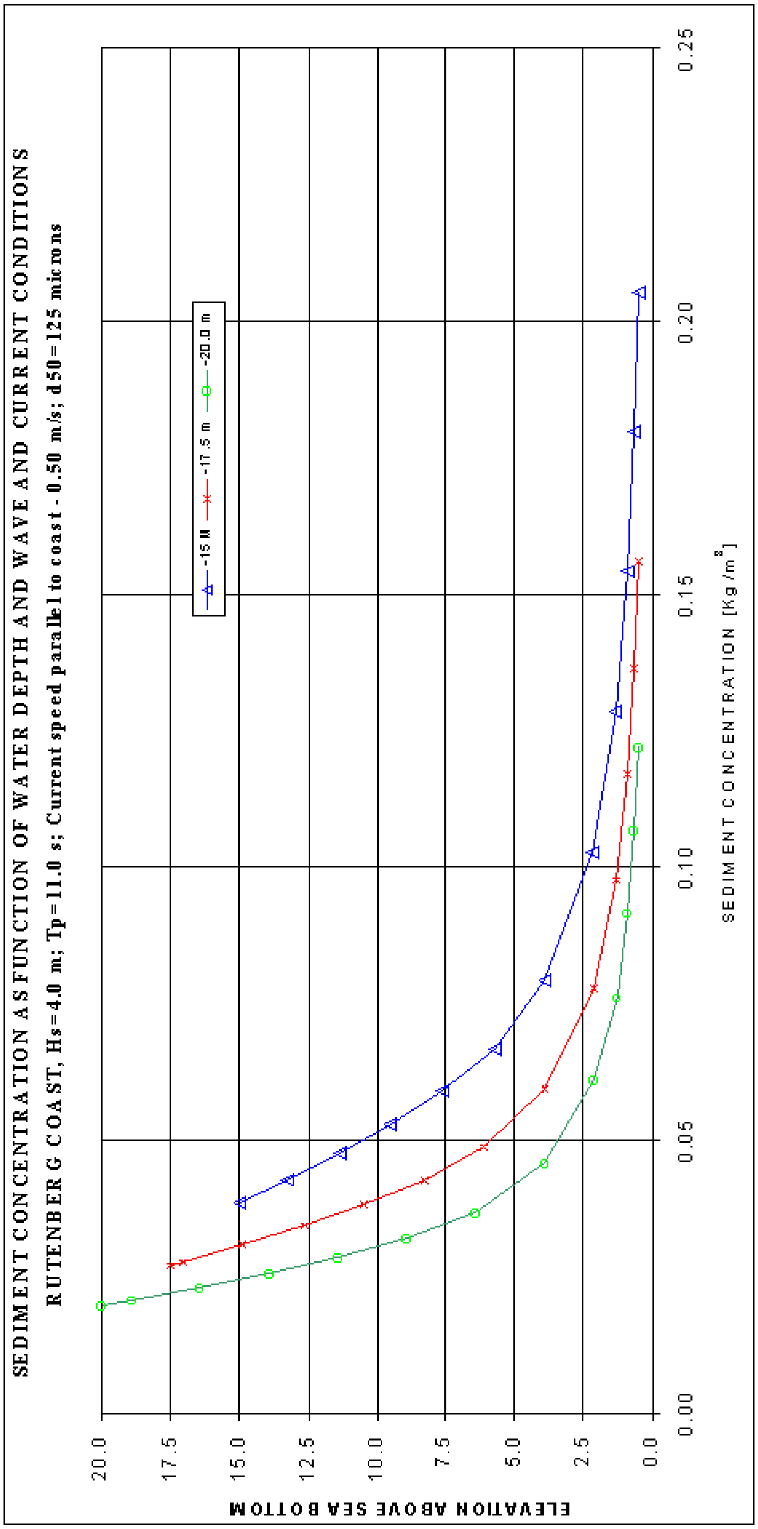

SEDIMENT CONCENTRATION AS FUNCTION OF WATER DEPTH AND WAVE AND CURRENT CONDITIONS
RUTENBERG COAST, Hs=4.0 m; Tp=11.0 s; Current speed parallel to coast - 0.50 m/s; d50=125 microns
-15 m
-17.5 m
-20.0 m
ELEVATION ABOVE SEA BOTTOM
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
SEDIMENT CONCENTRATION [Kg/m^3]
0.00
0.05
0.10
0.15
0.20
0.25

Figure No. 26

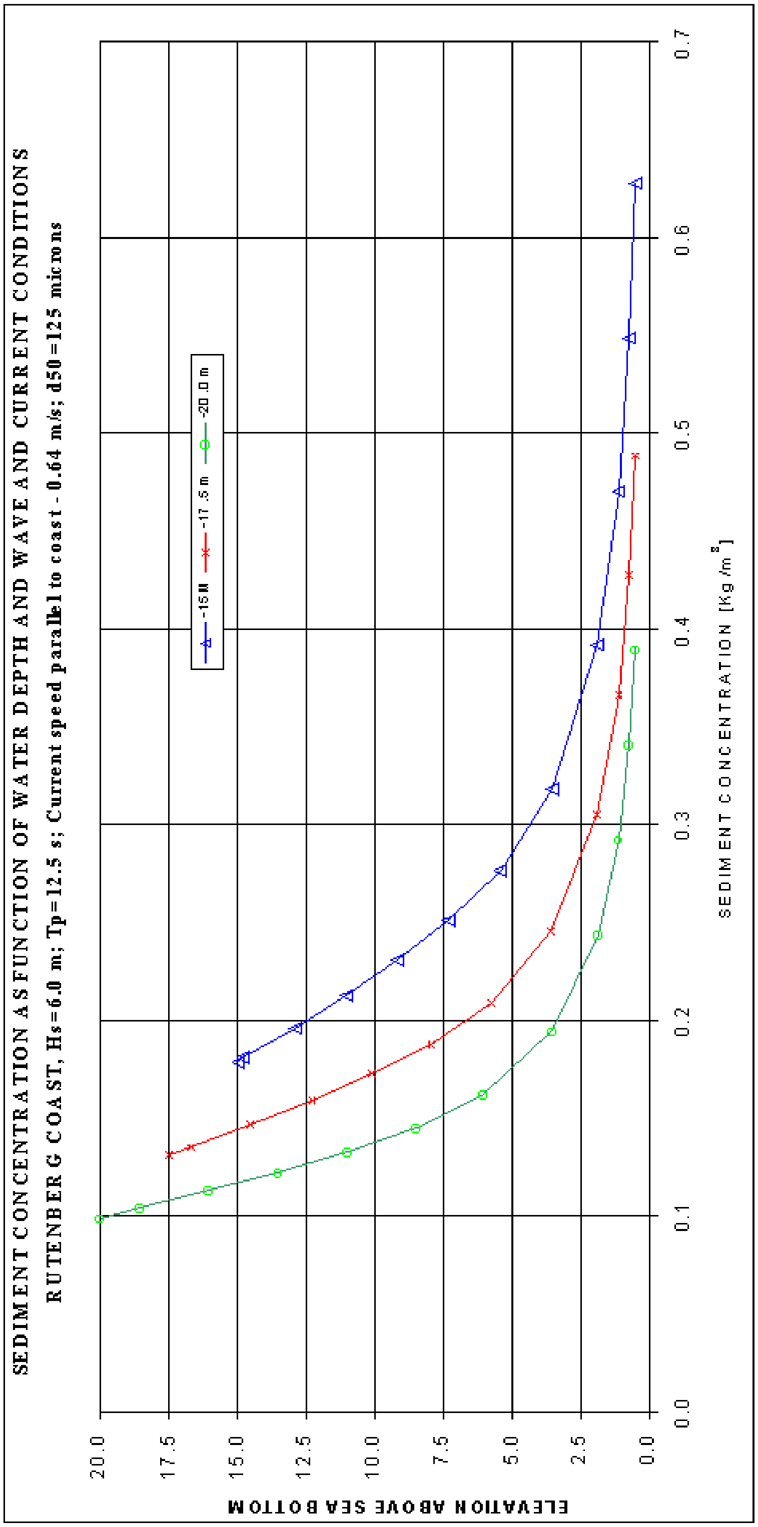

SEDIMENT CONCENTRATION AS FUNCTION OF WATER DEPTH AND WAVE AND CURRENT CONDITIONS
RUTENBERG COAST, Hs=6.0 m; Tp=12.5 s; Current speed parallel to coast - 0.64 m/s; d50=125 microns
-15 M
-17.5 m
-20.0 m
ELEVATION ABOVE SEA BOTTOM
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
SEDIMENT CONCENTRATION [Kg/m3]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

Figure No. 27

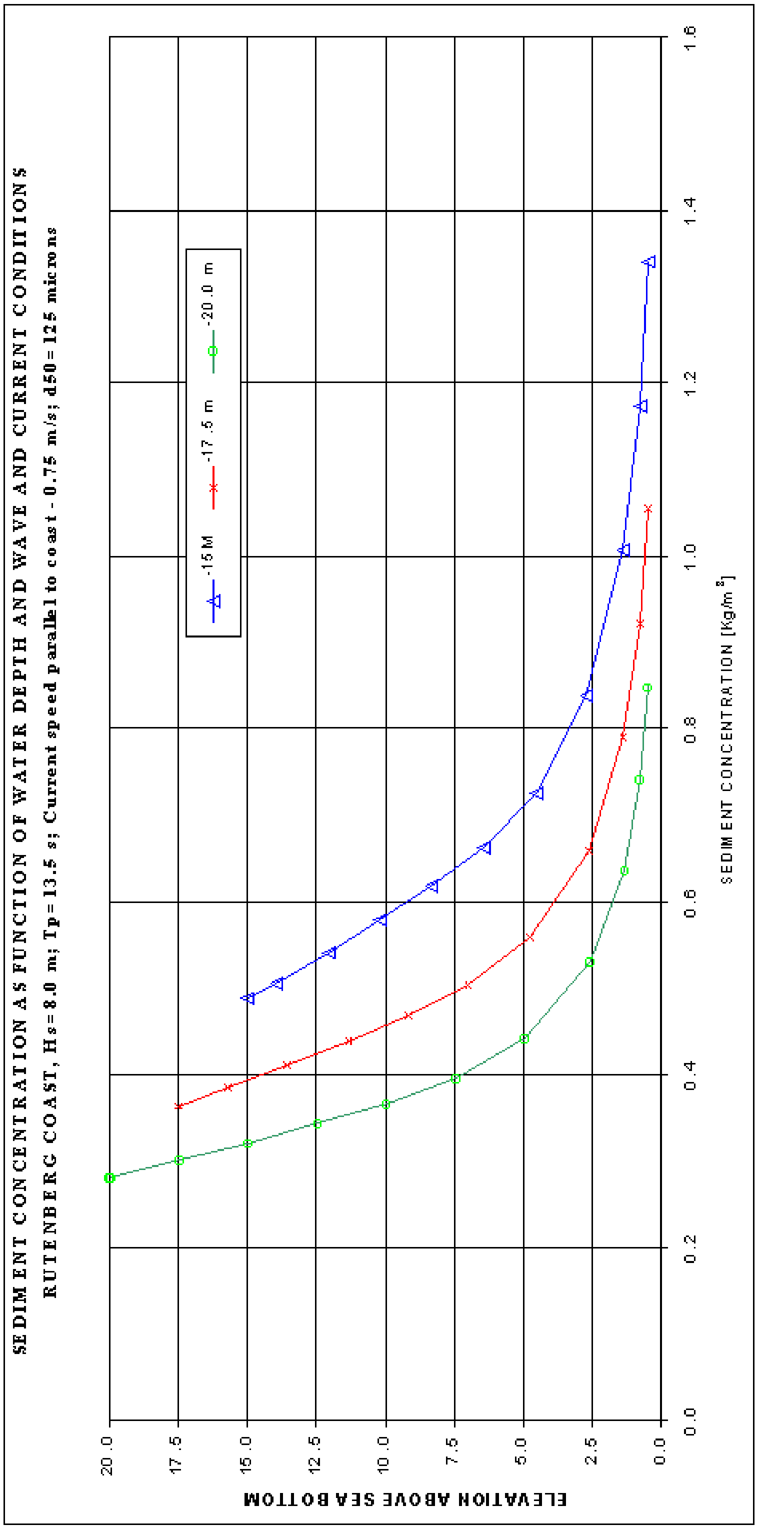

SEDIMENT CONCENTRATION AS FUNCTION OF WATER DEPTH AND WAVE AND CURRENT CONDITIONS
RUTENBERG COAST, Hs=8.0 m; Tp=13.5 s; Current speed parallel to coast - 0.75 m/s; d50=125 microns
-15 M
-17.5 m
-20.0 m
ELEVATION ABOVE SEA BOTTOM
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
SEDIMENT CONCENTRATION [Kg/m^3]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6

Figure No. 28

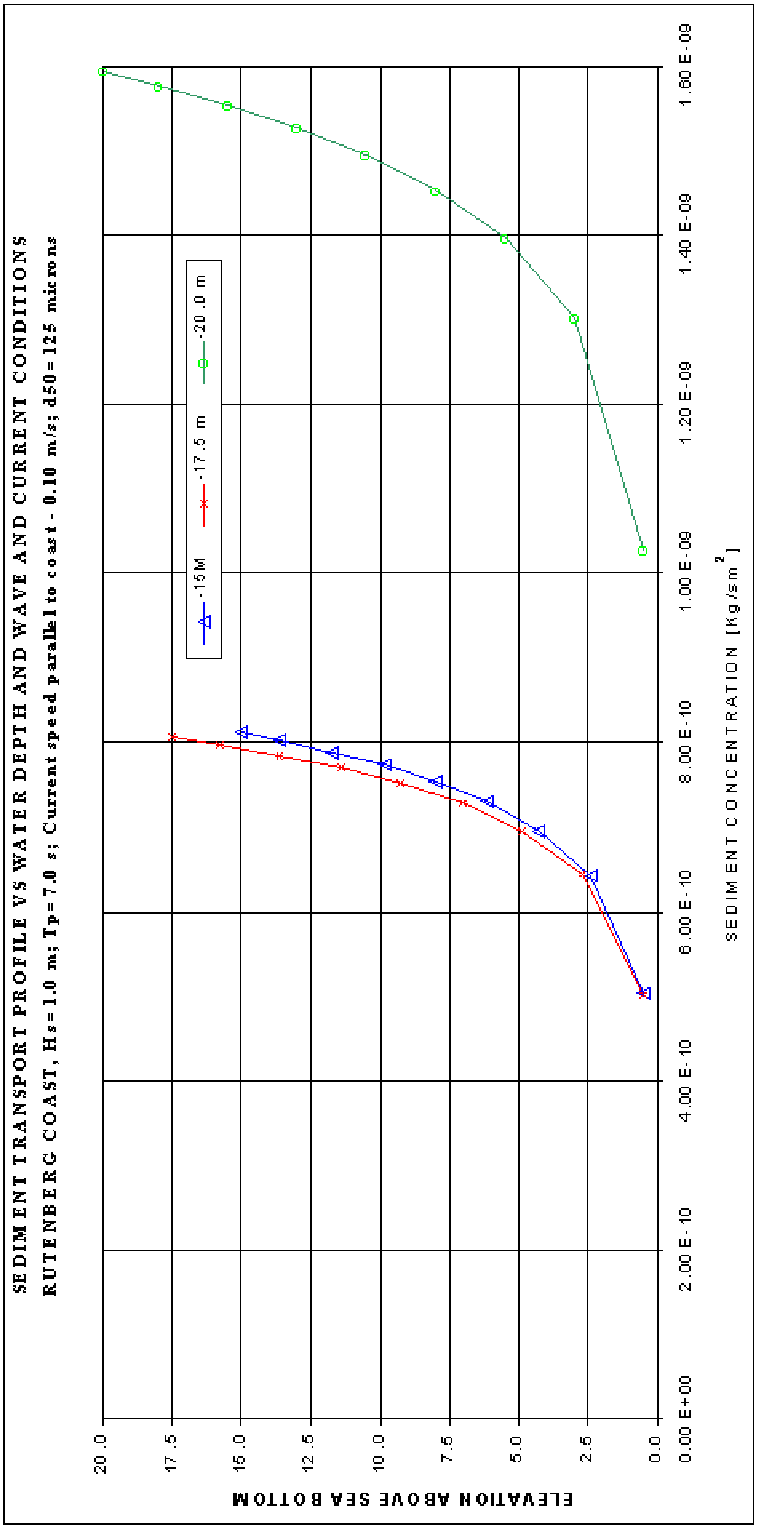

SEDIMENT TRANSPORT PROFILE VS WATER DEPTH AND WAVE AND CURRENT CONDITIONS
RUTENBERG COAST, Hs=1.0 m; Tp=7.0 s; Current speed parallel to coast - 0.10 m/s; d50=125 microns
-15 M
-17.5 m
-20.0 m
ELEVATION ABOVE SEA BOTTOM
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
SEDIMENT CONCENTRATION [Kg/sm^2]
0.00 E+00
2.00 E-10
4.00 E-10
6.00 E-10
8.00 E-10
1.00 E-09
1.20 E-09
1.40 E-09
1.60 E-09

Figure No. 29

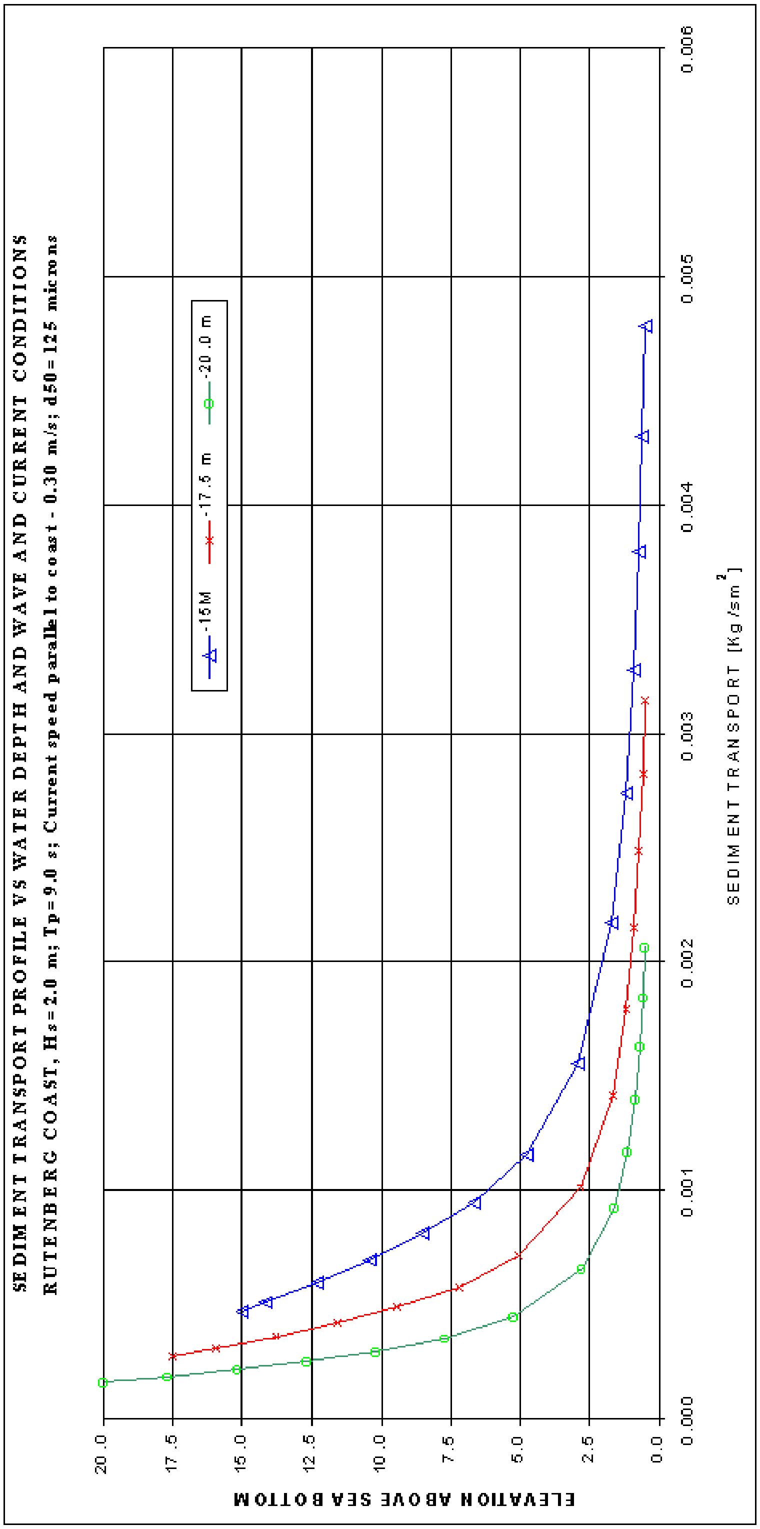

SEDIMENT TRANSPORT PROFILE VS WATER DEPTH AND WAVE AND CURRENT CONDITIONS
RUTENBERG COAST, Hs=2.0 m; Tp=9.0 s; Current speed parallel to coast - 0.30 m/s; d50=125 microns
-15 M
-17.5 m
-20.0 m
ELEVATION ABOVE SEA BOTTOM
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
SEDIMENT TRANSPORT [Kg/sm2]
0.000
0.001
0.002
0.003
0.004
0.005
0.006

Figure No. 30

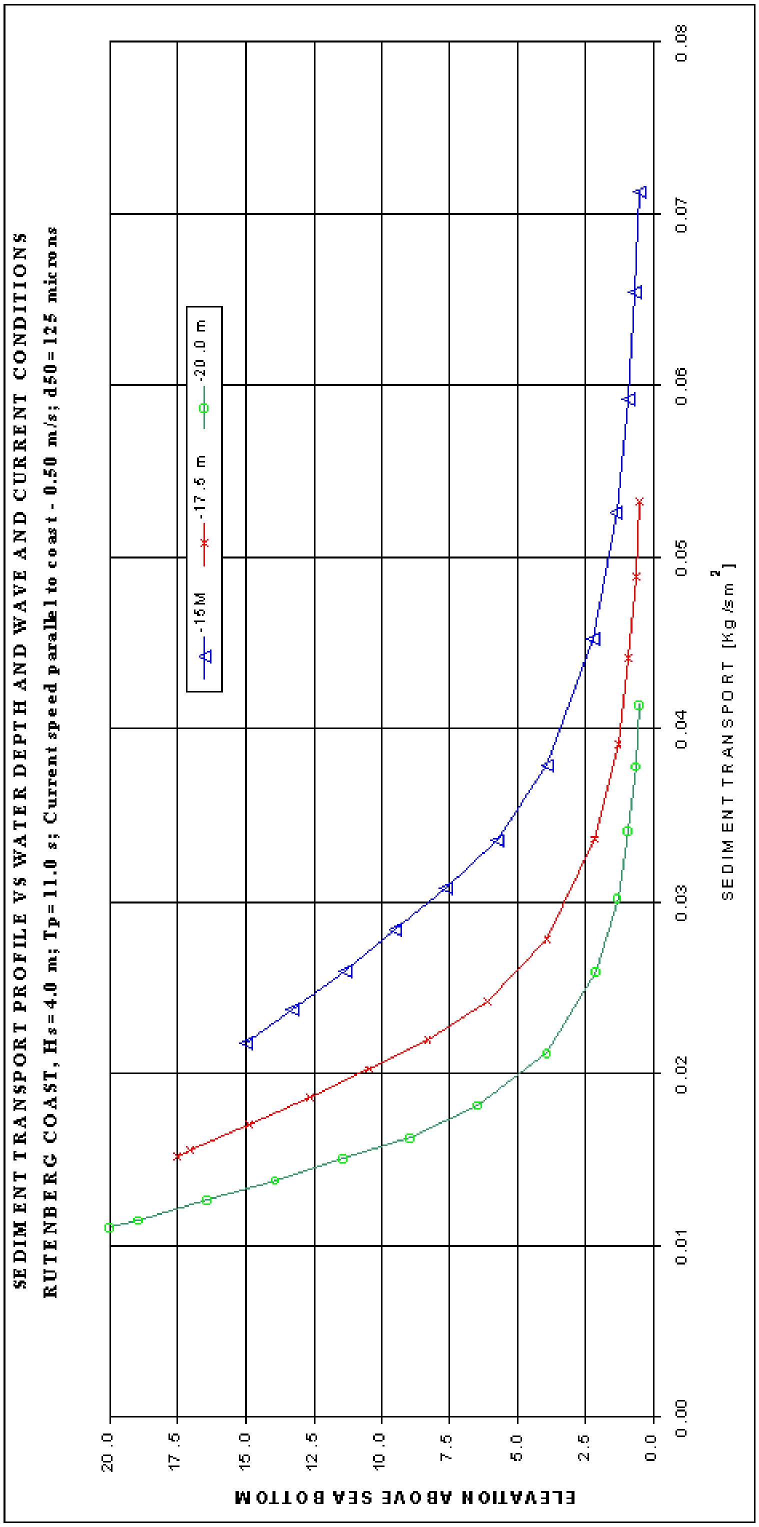

SEDIMENT TRANSPORT PROFILE VS WATER DEPTH AND WAVE AND CURRENT CONDITIONS
RUTENBERG COAST, Hs=4.0 m; Tp=11.0 s; Current speed parallel to coast - 0.50 m/s; d50=125 microns
-15M
-17.5 m
-20.0 m
ELEVATION ABOVE SEA BOTTOM
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
SEDIMENT TRANSPORT [Kg/sm^2]
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08

Figure No. 31

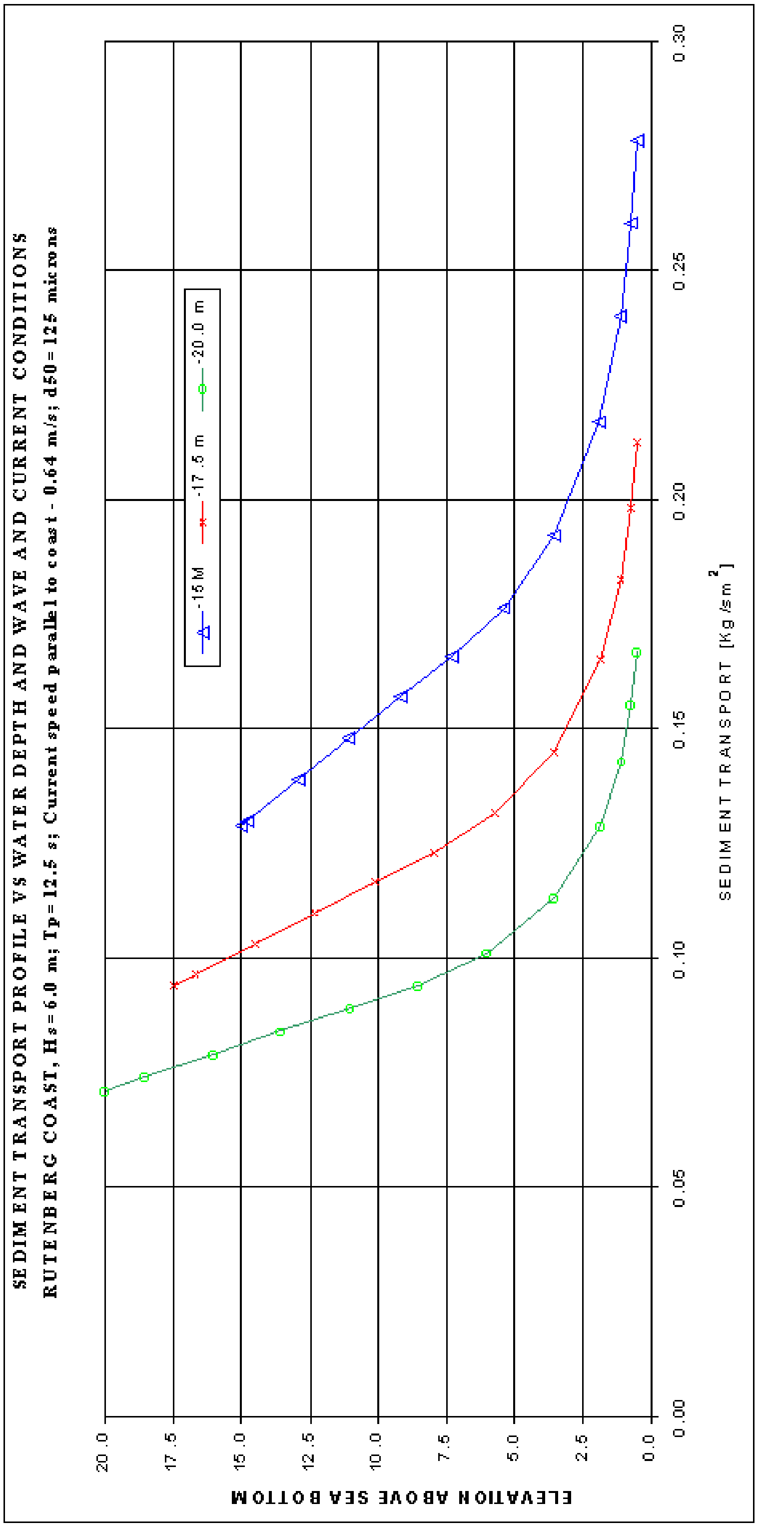

SEDIMENT TRANSPORT PROFILE VS WATER DEPTH AND WAVE AND CURRENT CONDITIONS
RUTENBERG COAST, Hs=6.0 m; Tp=12.5 s; Current speed parallel to coast - 0.64 m/s; d50=125 microns
-15 M
-17.5 m
-20.0 m
ELEVATION ABOVE SEA BOTTOM
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
SEDIMENT TRANSPORT [Kg/sm2]
0.00
0.05
0.10
0.15
0.20
0.25
0.30

Figure No. 32

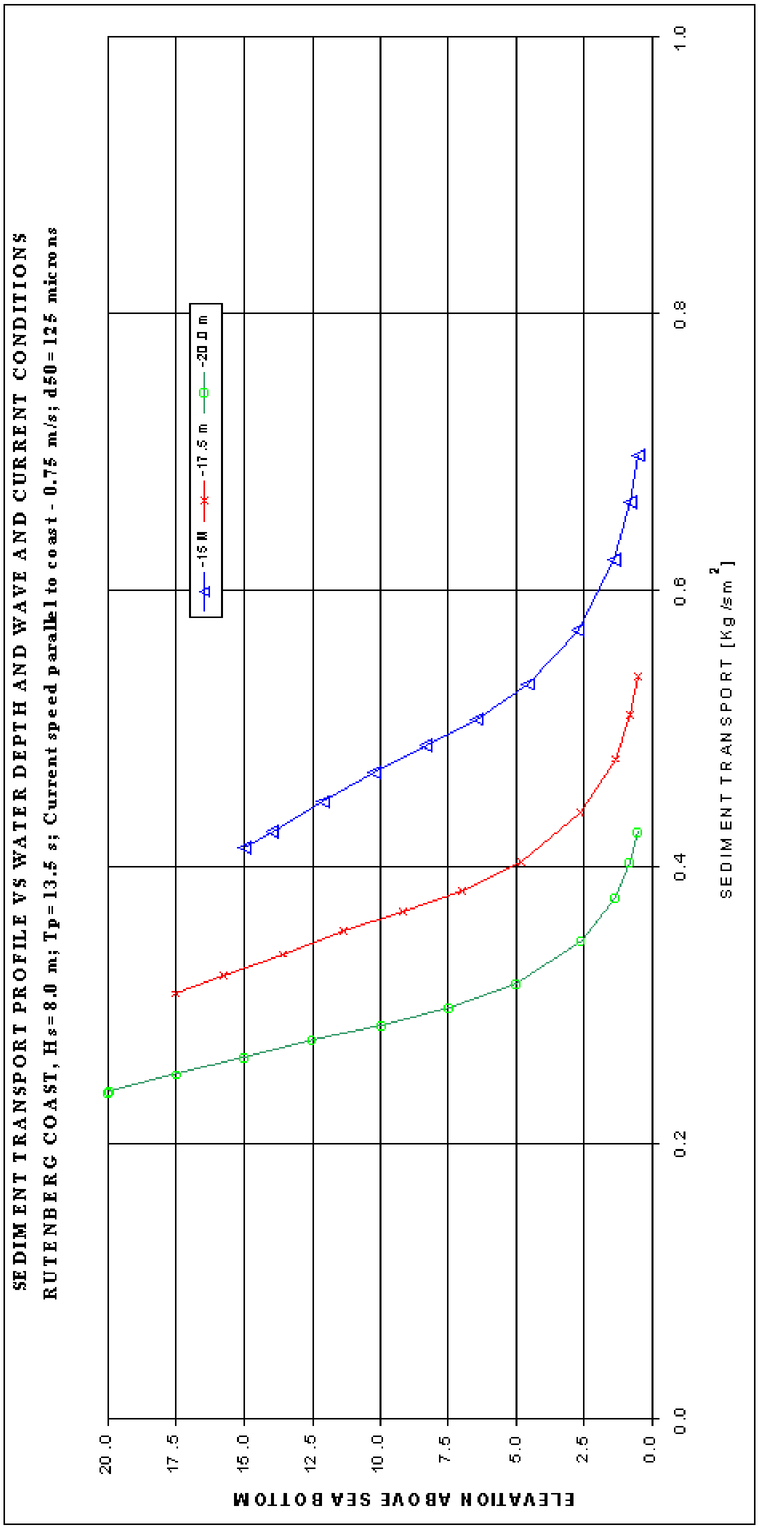
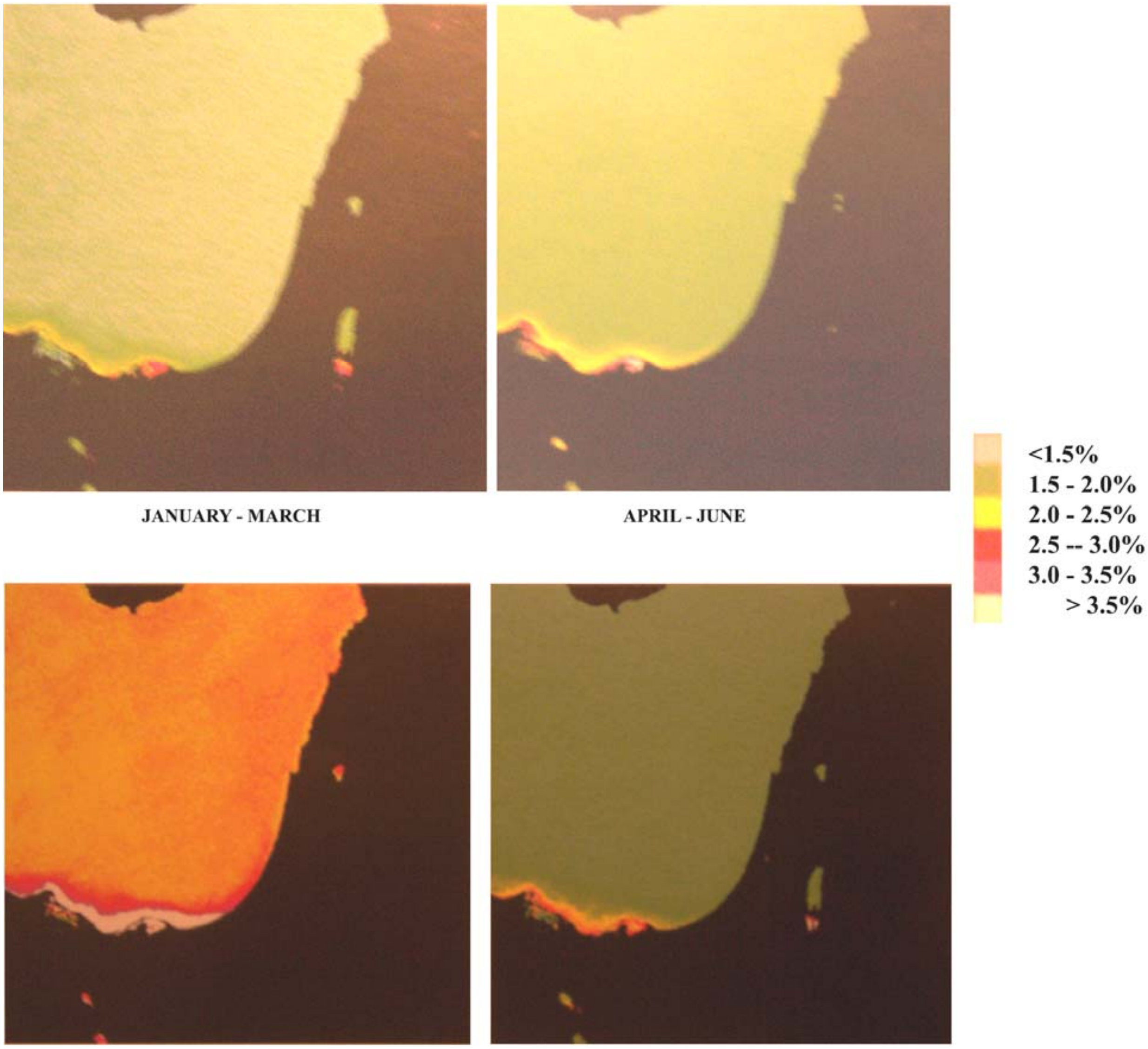

SEDIMENT TRANSPORT PROFILE VS WATER DEPTH AND WAVE AND CURRENT CONDITIONS
RUTENBERG COAST, Hs=8.0 m; Tp=13.5 s; Current speed parallel to coast - 0.75 m/s; d50=125 microns
-15 M
-17.5 m
-20.0 m
ELEVATION ABOVE SEA BOTTOM
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
SEDIMENT TRANSPORT [Kg/s m2]
0.0
0.2
0.4
0.6
0.8
1.0

Figure No. 33



JANUARY - MARCH

APRIL - JUNE

JULY - SEPTEMBER

OCTOBER - DECEMBER

Figure No. 34 – 1995 mean seasonal turbidity index value (REESAC, 1999)
(Based on NOAA/AVHRR satellite sensor -See influence of flows from the Nile delta)