# THE POSSIBILITY OF UTILIZING OCEAN TIDES AS A SOURCE OF ENERGY IN SARAWAK

WAN AZRAYA BT. WAN ADNAN

Universiti Malaysia Sarawak
2000

# THE POSSIBILITY OF UTILIZING OCEAN TIDES AS A SOURCE OF ENERGY IN SARAWAK

by

**Wan Azraya bt. Wan Adnan**

This report is submitted in partial fulfillment of the requirement for the degree of Bachelor of Engineering (Hons.) Mechanical Engineering and Manufacturing System from the Faculty of Engineering
Universiti Malaysia Sarawak
2000

**Borang Penyerahan Tesis**
**Universiti Malaysia Sarawak**

**BORANG PENYERAHAN TESIS**

Judul: **THE POSSIBILITY OF UTILIZING OCEAN TIDES AS A SOURCE OF ENERGY IN SARAWAK**

**SESI PENGAJIAN: 1997/2000**

Saya **Wan Azraya bt. Wan Adnan**

Mengaku membenarkan tesis ini disimpan di Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dengan syarat-syarat seperti berikut:

1. Hakmilik kertas projek ini adalah dibawah nama penulis melainkan penulisan sebagai projek bersama dan dibiayai oleh UNIMAS, hakmiliknya adalah kepuyaan UNIMAS.
2. Naskah salinan didalam bentuk kertas atau mikro hanya boleh dibuat dengan kebenaran bertulis daripada penulis.
3. Pusat Khidmat Maklumat Akademik, UNIMAS dibenarkan membuat salinan untuk pengajian mereka.
4. Kertas projek hanya boleh diterbitkan dengan kebenaran penulis. Bayaran royalti adalah mengikut kadar yang dipersetujui kelak.
5. * Saya membenarkan/tidak membenarkan Perpustakaan membuat kertas salinan projek ini sebagai bahan pertukaran diantara institusi pengajian tinggi.
6. ** Sila tandakan ☑

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan dimana penyelidikan dijalankan)

☑ TIDAK TERHAD

Disahkan oleh

(TANDATANGAN PENULIS) | (TANDATANGAN PENYELIA)

Alamat tetap: 1133 Jalan Penghiburan, 24000 Kemaman, Terengganu.

EN. NAZERI ABDUL RAHMAN
Nama Penyelia

Tarikh: 11 April 2000 | Tarikh: 11 April 2000

**CATATAN** * Potong yang tidak berkenaan
** Jika Kertas Projek ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyertakan sekali tempoh kertas projek

# APPROVAL SHEET

This project entitled "THE POSSIBILITY OF UTILIZING OCEAN TIDES AS A SOURCE OF ENERGY IN SARAWAK" was presented by Wan Azraya bt. Wan Adnan as a partial fulfillment for the Bachelor of Engineering (Hons.) Mechanical Engineering and Manufacturing System degree programme is hereby read and approved by:

Mr. Nazeri Abdul Rahman
( Project Supervisor )

Date: 11/4/2000

# ACKNOWLEDGEMENTS

The author would like to express her sincere gratitude and appreciation to her supervisor, Mr. Nazeri Abdul Rahman for his guidance, advice and thoughful tips throughout the duration of the project. A word of thanks also goes to her friends for their motivation, encouragement and invaluable friendship. Most importantly, special thanks to her beloved family for their love and support.

# ABSTRACT

Tidal energy is the kinetic energy of the earth-moon-sun system. Variations in water level along coastlines can be used to drive turbines to produce the electric current needed. The objective of this study is to do a research about the possibility in using the ocean tides as a source of energy in Sarawak in order to accomplish the increasing energy demand. The study covered the inquisition of Batang Mukah River and Niah River by referring to the map and calculation in order to find the amount of energy that could be harvested at both candidate locations. The findings of this study showed that Batang Mukah River can harvest about 2.34 GW of electricity and Niah River is 1 GW. The research has shown that Batang Mukah and Niah River have the possibility to be utilized as a source of energy because both rivers have the required tidal range for the construction of tidal power plant.

# ABSTRAK

Tenaga pasang surut merupakan tenaga kinetik yang melibatkan sistem bumi-bulan-matahari. Perubahan dalam paras air laut di sekitar persisiran boleh digunakan untuk menggerakkan turbin bagi menjana tenaga elektrik yang diperlukan. Kajian ini bertujuan untuk menyelidiki tentang kemungkinan untuk menggunakan pasang surut air laut sebagai sumber tenaga di Sarawak bagi memenuhi permintaaan tenaga yang kian meningkat. Kajian ini meliputi penyelidikan ke atas Sungai Batang Mukah and Sungai Niah dengan merujuk kepada peta dan pengiraan bagi mendapatkan jumlah tenaga yang boleh dijanakan di kedua-dua tempat. Hasil kajian menunjukkan Sungai Batang Mukah boleh menjana dalam 2.34 GW tenaga elektrik dan Sungai Niah sebanyak 1 GW. Kajian ini sekaligus menunjukkan Sungai Barang Mukah dan Niah mempunyai kemungkinan untuk dijadikan sebagai sumber tenaga disebabkan kedua-dua sungai ini mempunyai kadar perbezaan pasang surut yang diperlukan untuk pembinaan pusat janakuasa.

# TABLE OF CONTENTS

**Chapter 3 : SITE INQUISITION AND JUSTIFICATION**



**Chapter 4 : RESULTS AND DISCUSSION**



**Chapter 5 : CONCLUSION AND RECOMMENDATION**

# LIST OF FIGURES

# LIST OF TABLES

# NOTATIONS

| | | |
|---|---|---|
| $\rho$ | : | density of water ( kg $m^{-3}$ ) |
| $A$ | : | cross sectional area of river ( $m^2$ ) |
| $E$ | : | potential energy ( W ) |
| $E_o$ | : | maximum potential energy ( W ) |
| $g$ | : | gravitational acceleration ( m $s^{-2}$ ) |
| $l$ | : | length of river ( m ) |
| $m$ | : | body of mass ( $m^3$ ) |
| $P$ | : | average power ( W/$m^2$ ) |
| $r$ | : | mean tidal range ( m ) |
| $w$ | : | wide of river ( m ) |

# *Chapter 1*

# *INTRODUCTION*

## 1.1. Introduction to Tides

Tides can be defined as the cycle of rise and fall in sea level, which is generated by the gravitational and rotational forces on the earth. This includes the gravitational forces from the moon and the sun. The 'heaping' action from the horizontal flow of water toward two regions of the earth that represent positions of maximum attraction of combined lunar and solar gravitational forces will create the high tide. Therefore, a compensating maximum withdrawal of water from regions around the earth midway between these two humps will produce the low tides. With respect to these two tidal humps and two tidal depressions, the earth's daily rotation will produce an alternating of high and low tides. Alternation of high water and low water can make a complete tidal cycle. [Hatheway, 1988]

Every 24 hours 50 minutes, the moon makes one complete revolution about its own axis and it revolves around the earth in an elliptical orbit every 29.54 days. During the lunar day (24 hours 50 minutes) the earth's rotation and the forces exerted by the sun and the moon will produce two complete tidal cycles of the same duration. Each cycle take 12 hours 25 minutes and call as 'semidiurnal' and this can be seen in **Figure 1.1** [National Ocean Services, 1997]. The height of the high tide that represents by point

A is same as point A' 12 hours later. These equal spaced time of successive high and low tides occur twice daily and it also can be seen from the top diagram in **Figure 1.2**. In **Figure 1.1**, point B is beneath a bulge in the tidal envelope. One-half day later, at point B' it is again beneath the bulge, but the height of the tide is obviously not as great as at B. This situation gives rise to a twice-daily tide, displaying unequal heights in successive high or low waters, or both pairs of tides. This type of tide, exhibiting a strong diurnal inequality and known as a mixed tide and also can be seen from middle diagram in **Figure 1.2**.

As depicted, the point C is seen to lie beneath a portion of the tidal force envelope. One-half day later, as this point rotates to position C', it is seems to lie above the force envelope. Therefore, at this location, the tidal forces present produce only one high water each day. The resultant diurnal type of tide is shown in the bottom diagram of **Figure 1.2.**

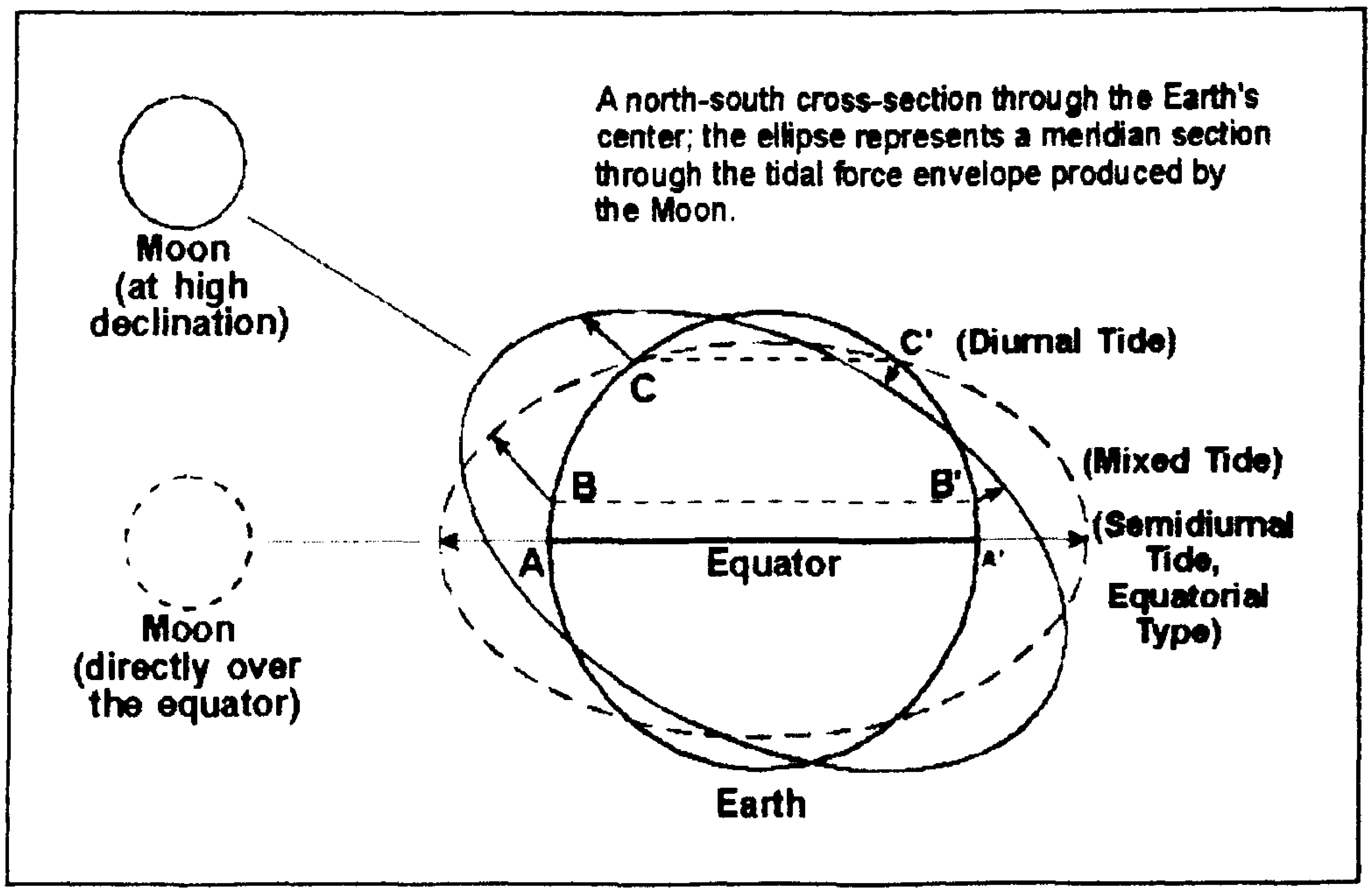


**Figure 1.1 :** The Moon's Declination Effect and the Diurnal Inequality; Semidiurnal, Mixed and Diurnal Tides [ National Ocean Services, 1997 ]

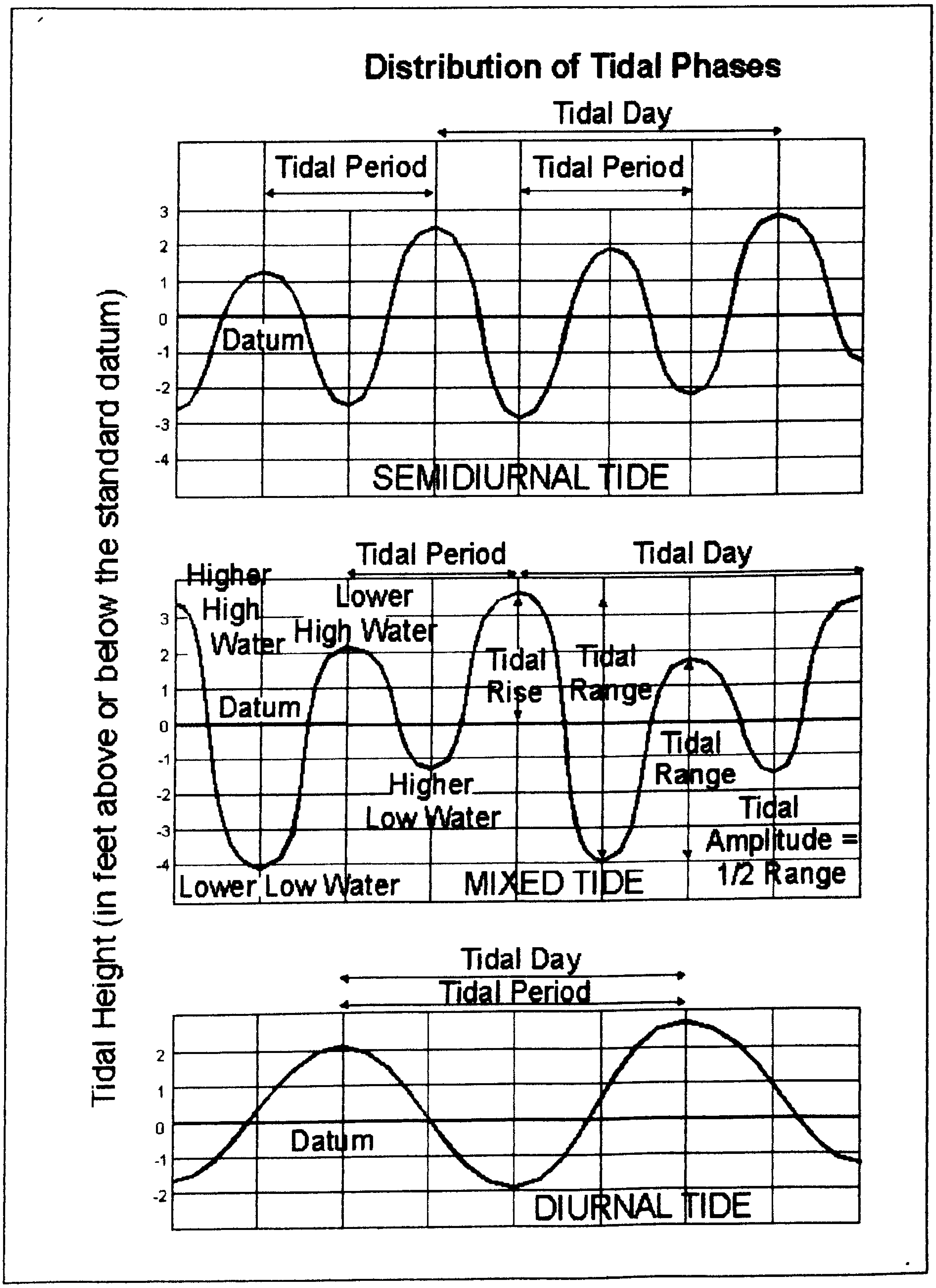


**Figure 1.2** : Principal Types of Tides [ National Ocean Services, 1997 ]

**Figure 1.3** shows the effects of the position and forces of the earth, the moon and the sun to the tidal range. When the sun, the moon and the earth are almost in one line, the tides have their maximum tidal range and are known as the spring tides. Nevertheless, when the moon-earth-sun angle is a 90°, the tides have their minimum tidal range and are known as the neap tides [Giancoli, 1991].

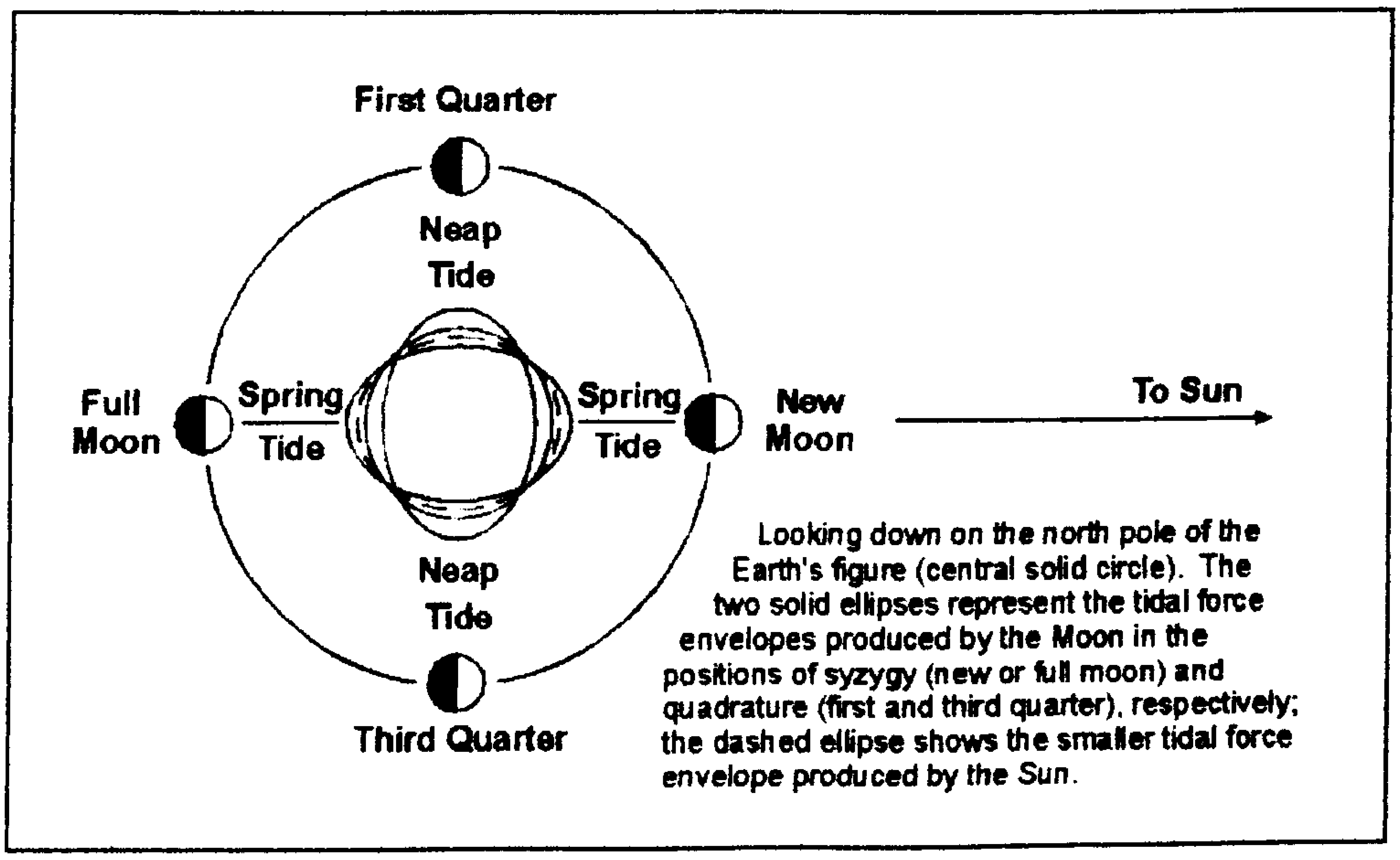


**Figure 1.3 :** The Combination of Forces of Lunar Origin Producing the Tides [ National Ocean Services, 1997 ]

**Figure 1.4** shows the effect of the position the earth and the moon to the tidal range. Since the moon follows an elliptical path, the distance between the earth and moon will vary throughout the month by about 31 000 miles. The moon's gravitational attraction for the earth's waters will change in inverse proportion to the third power of the distance between the earth and the moon.

Once each month, when the moon is nearest to the earth or also called as perigee, the tide-generating forces will be higher than usual, thus producing above average ranges in the tides and the largest spring tides will occur. Approximately, two weeks later, when the moon in apogee, the farthest distance from the earth, the lunar tide raising force will be smaller, the tidal ranges will be less than average and the smaller neap tides will occur.

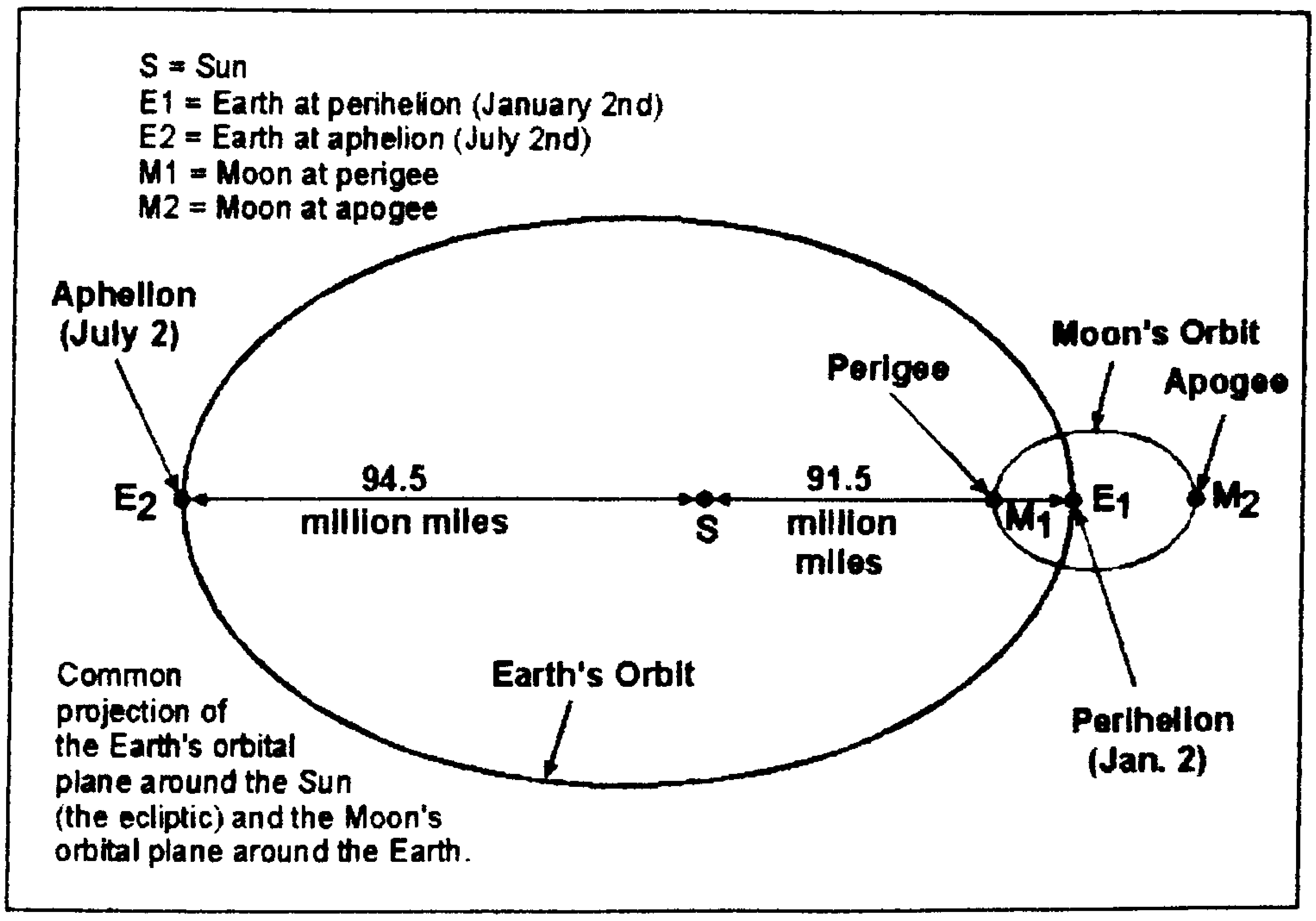


**Figure 1.4 :** The Lunar Parallax and Solar Parallax Inequalities [ National Ocean Services, 1997 ]

Similarly, in the earth-sun system, when the earth is closest to the sun or perihelion, about January 2 of each year, the tidal ranges will be enhanced and spring tide will be occurred. When the earth is farthest from the sun or aphelion, around July 2, the tidal range will be reduced and there will be neap tide. The ratio between the greatest spring tide and the smallest neap tide can be up to 3:1 [Avallone, 1996].

## 1.2. Introduction to Tidal Power

Tidal power can be obtained from the flow of water that caused by the rising and falling of the tides in partially enclosed basins.

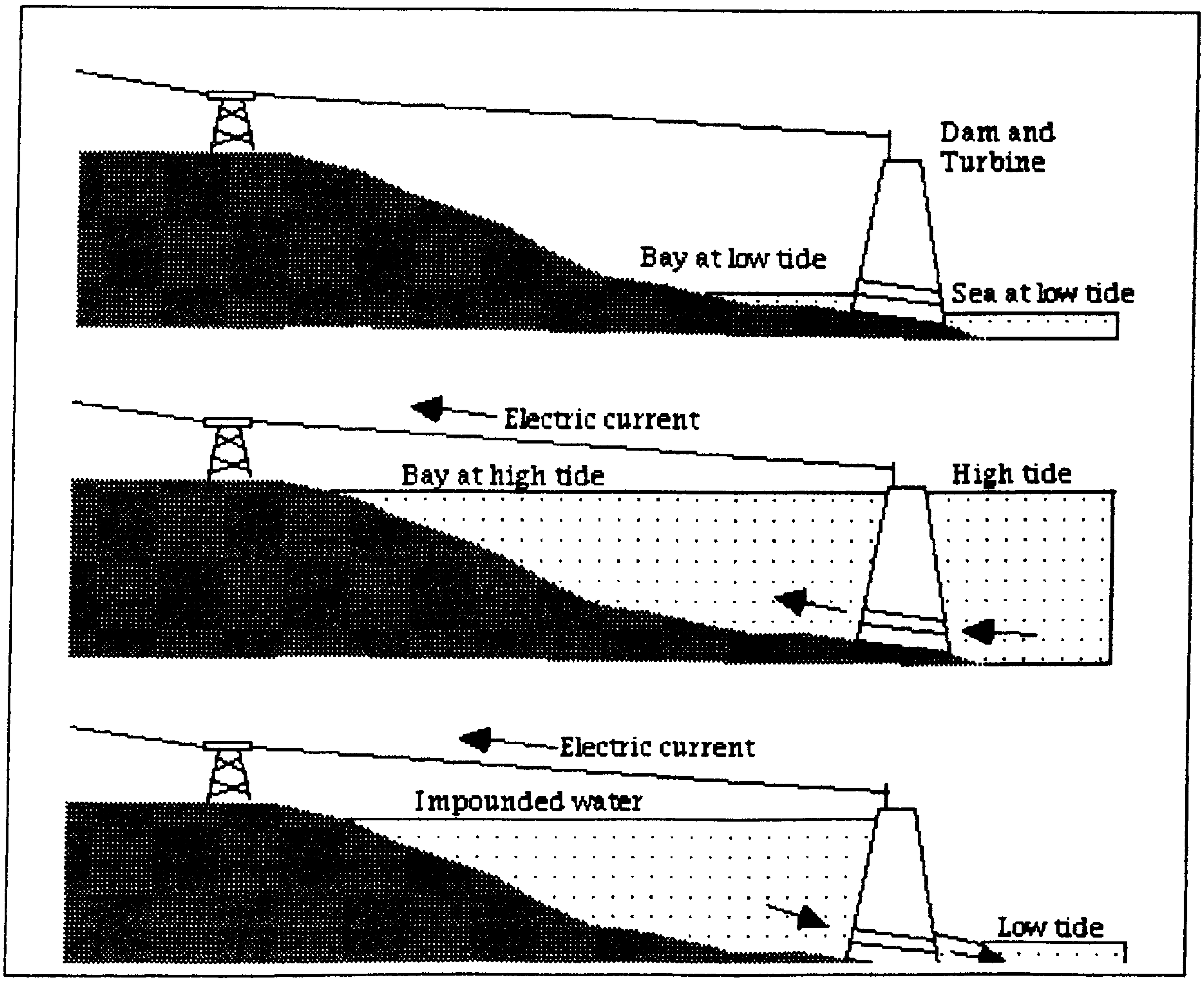


**Figure 1.5** : Process of Tidal Energy Produced [ Buckley, 1996 ]

**Figure 1.5** showing that the tidal energy can be converted into potential energy by enclosing the basins with dams. This creates a difference in water level between the ocean and the basin. The flow of water when the basin is filling or emptying can be used to drive the turbines, and simultaneously produce the electric current needed.

### 1.2.1. Tidal range

The difference in height or feet, between consecutive flood and ebb tides that occurred at certain places is known as the amplitude or range. The flood tide occurred when the sea is rising and when the sea is falling, it is an ebb tide.

The tidal ranges in estuaries or bays are caused by the interaction of two types of wave. The first is the tidal wave advancing from the open sea and the second is the reflected waves from the sides of the estuary. Depending on the shape of the estuary and the period of tide, these two waves can reinforce each other at certain times, causing the amplification. Peak amplification occurs at resonance.

In the open ocean, the tidal range is typically about 1 m and in mid-ocean the tidal ranges are around 60 cm. Along the coast, the tidal range increases to about 2 m and in some estuaries of deep narrow bays it can be up to 16 m. [Wick, 1981]. The shoreline physical characteristics and the continental shelf influence these tidal ranges.

Most of the extreme tidal ranges that can be found around the world occur in large estuaries which provide a single funnel effect, such as the Bay of Fundy in Canada and the River Severn in England. However, a very high tide also can be found along some open coast, such as the area adjacent to the Cotentin Peninsula in France. In locations such as the Bay of Fundy, tides is up to 13.5 m. [Wick, 1981]

Several natural forces control complex times of variations in tidal range. But, tidal power plant can supply the extra power by using the major pump storage or with a power network.

One of the natural forces that control the high tidal range in the Bristol Channel is the Coriolis effect. This force is exerted by the rotation of the earth on a moving stream that causes the water to slope up on shore. One such example can be observed in the Irish Sea. A flood tide induces a northward flow where the sea piles up on the eastern shore to a height of about 120 cm and an ebb tide induces a southward flow with the sea piles up to 120 cm on the western shore. Along the Cotentin Peninsula of France also have been anticipated to have the Coriolis effect. [Walter, 1981]

Offshore storms and hurricanes also caused significant increases in local tide levels for a short period of time, which resulting in caustic flooding of low coastal areas. Additional nonastronomical factors such as configuration of the coastline, local depth of the water, ocean-floor topography and other hydrographic and meteorological influences may play an important role in altering the range of high and low tides and change the time of tides arrival.

## 1.3. Tidal Power Scheme and Modes of Operation

Before deciding the candidate schemes, all aspects of a proposed tidal project should be investigated. The choices between the single effect (one way tide working) or double effect (two-way tide working) power station requires a careful analysis.

There are number of different schemes which can be grouped into two main combinations, depending on whether one or two basins are used or pump storage might be used to help increase the energy needed.

*i.* *Single basin, generation only on the ebb tide*

It allows the incoming tide to flow through sluice gates and the turbine passageways. The tidal plants are closed at high tide and the water is retained until the sea has ebbed sufficiently for the turbines to operate. This is normally at about half the tidal range. Initially, the flow is restricted to maintain a high head and to operate the turbines at maximum efficiency. Later in the cycle the turbines are usually operated at maximum power.

*ii.* *Single basin, generation only on the flood tide*

It is the reverse of ebb generation and has a number of potential disadvantages. The main one being the prolonged periods of low tide experienced above the dam. A second disadvantage is that the amount of energy would be less than with an ebb generation scheme, as the surface area of estuary decreases with depth.

iii. *Single basin, generation with both the ebb and the flood tides*

This does not result in a greatly increased power output. Neither phase of the cycle can be taken to completion because of the need to reduce or increase levels in the basin for the next phase. There are also economic disadvantages. The turbines are more complex and less efficient if they are required to operate in both directions and the turbine water passages must be longer. An advantage is that power is available four times in the tidal day, so it provides greater operating flexibility.

iv. *Double basin*

They could operate as two independent two-way generation schemes. In another form water would always flow from the higher-level basin to the second lower-lever basin. The second basin could only be emptied at low tide. It often included provision for pumped storage.

v. *Double basin with pumped storage*

In certain cases pumped storage may be needed to maintain the level of power generation. In an ebb generation system, the use of pumps to increase the level of water contained in the basin at high tide appears to be attractive.

Pumping involves some loss of overall efficiency and it can produce extra power to meet the power demand. The pumped storage usage of the tidal generator will increase the electrical and financial output without real additional capital cost and shift the timing of the generation into the more profitable peak hours.

## 1.4. The Advantages of Tidal Power Plant

Tidal power plants use a free and unlimited fuel and produce the clean energy that has minimum environmental impacts compared to the most conventional power project. By replacing the fossil fuel resources, tidal plant also has extra financial benefits such as pollution credits, freedom from fuel cost rises, exception from global warming initiatives and the general reliability and predictability of low-head hydroelectricity.

Besides small land requirement, there is also very high plant reliability with a long plant life ( 75 to 100 years ). Power output of the tidal power plant is both predictable and dependable. Related to power plant structures or operations, there will be few public safety hazards. Even though it only operates part time, it provides a stable and domestic energy resource. The project itself may also have tremendous interest to tourist and local people to visit and increases the regional employment.

## 1.5. The Disadvantages of Tidal Power Plant

Even the tidal power plant is an environmental friendly power source, it also has an effect to the environment. It effects delicate sea life and injured shell fishbeds that was harmed by pollution and over harvesting. This fish migration might be impeded and killed by passing through the turbines. Therefore, the aquatic ecosystem will always be affected by any changes in turbidity and salinity and will effect the food chain which causes school of fish to move to different waters and makes people who fish for a living lose their jobs.

The location and nature of the inter tidal zone will be changed, and the tidal regime is changed downstream. Water level both in the basin upstream of the barrage can effect the seaward. Tidal flows reduce the strength of the currents upstream of the barrage. Land drainage may also be affected inside the barrage because of higher low-water levels. Mixing will occur less in the water above the basin because of reduced currents and tidal excursions. Sedimentation may occur in the basin and could lead to a slow and possibly small reduction in basin volume.

The movement of ships will be affected as the dams blocked the passage. By using locks, this problem can be solved, but passing through locks may slow down the ship movement. Industry could benefit during construction but may have to adopt higher standards in dealing with possible liquid effluent pollution. After the construction of a barrage, sea defenses might be less liable to storm damage.

## 1.6. The Characteristic of the Rivers at Sarawak

In Malaysia, Sarawak is one of the states which has many rivers. River has become an important asset for Sarawak's resident either for transportation or to be used in their daily life. The climate in Sarawak is typically wet equatorial. Rainfall is heavy and annual average is about 2500mm and humidity is always high. The high level of rainfall will cause a high tidal range to Sarawak rivers. Therefore, tidal range in Sarawak rivers also has a potential to be used as a location to harvest tidal energy. However, in order to build a tidal power plant, the shape of the estuary and river is also required to be considered. There are many rivers at Sarawak which is suitable in