Water Awareness and Charge Certificate Manual

Module 24: Meteorology

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Module Contents

Module Title	Comments	Rev No	Revision Date
Module 24: Meteorology	Initial Release	1.0	13 Sep 2012
Module 24: Meteorology	Paragraph on Dams	1.1	3 Jan 2016
Module 24: Meteorology	Outcomes Added	1.2	14 Jan 2018

Outcomes

After completing this module, the certificate holder will:

- Be able to explain the fundamental causes of weather
- Be able to recognize weather patterns
- Be able to classify wind and associated wave action
- Be able to explain the effect of large dams on weather patterns.

1 Introduction

Meteorology is the study of weather and climate. Weather is the conditions experienced over a short period of time – between 24 hours and 7 days. Climate refers to long term averages of weather over a season, year or longer.

The weather is probably the most important factor to consider when planning a trip or expedition. Each geographical area has a weather pattern of its own. The mountains have a different pattern to the Highveld and the coastal zones differ again even to being different along the length of coastline and east or west coasts. Large bodies of water also create their own micro climate due the difference in heat retention between land and water.

It is far better to have an indication of what weather to expect before commencing any journey and avoid unpleasant surprises. Learn to judge local weather conditions through experience and obtain current forecasts. Newspapers, TV and the Internet are all good sources of weather information. There is also a meteorological office at all major airports and harbours and they are only too willing to be of assistance

Local knowledge should also be sought before beginning journeys or activities.

Rather be safe than sorry but there is always going to be that time when, after all precautions have been taken, the weather will turn bad. This is when the skills of the person in charge will really be put to the test and the lives of others are dependent upon your decisions. Rather take early evasive action than place yourself in danger. Always exercise great caution in fog, mist heavy rain or any condition of poor visibility and head for the nearest safe shore.

2 Atmospheric Pressure

The earth is surrounded by a thin layer of gases, known as the atmosphere. Atmospheric pressure is the result of gravity acting on the gases and is measured in millibars. The average atmospheric pressure at sea level is 1013mb and it decreases with altitude.

Air pressure is measured with a barometer, commonly referred to as a glass. A barometer can assist in predicting the incoming weather.

- Falling pressure indicates bad weather is on its way
- Rising pressure indicates good weather is on its way
- In general, high pressure areas are characterised by clear calm weather, while lows bring rain and strong winds. If the pressure is high and remains steady, good weather is likely to prevail

On the Highveld, the pressure difference between good and bad weather is quite small. For this reason, barometers are not as effective on the Highveld as they are at sea level.

3 Winds

Winds are produced by differences of air temperature, and hence air density, between two regions of the earth. The steeper the pressure gradient between these two area, the stronger the wind force, When a difference in density exists between two adjacent air masses, the air tends to flow from the regions of higher to lower pressure. Wind is always named by the direction from which it comes

To be accurate, wind is measured in knots, but the generally accepted method for quantifying wind speed is using the Beaufort scale. See section 3.3

No small craft should ever be on the water in a force 7 or higher.

3.1 Gradient winds

Gradient winds are an attempt to equalise the air pressure between Highs and Lows, However due to the Coriolis Effect on bodies in motion, it travels pretty much in the parallel to the isobar lines. The steeper the pressure gradient, the stronger the wind. In the southern hemisphere the gradient winds travel anti-clockwise around highs and clock wise around lows. And the whole weather pattern moves in a west to east direction. So the wind actually blows around the high cell like this:

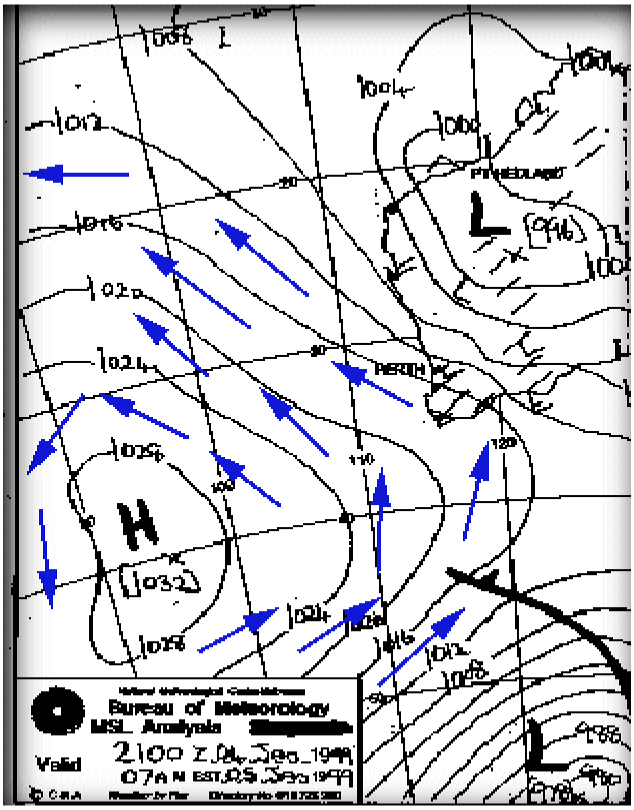
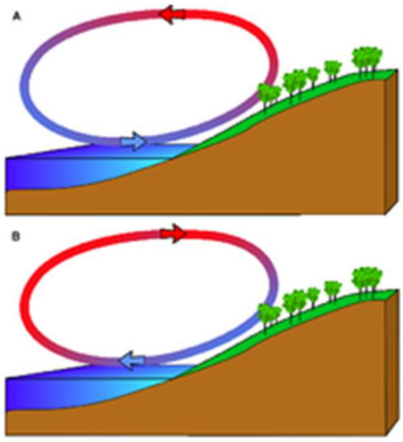


Figure 1: Synoptic chart with winds

3.2 Sea and land breezes

During the day, the effect of the sun causes the temperature of the land to rise significantly, while the temperature of the sea remains stable. By the afternoon, the land is heating the air directly above it, causing a drop in density. The warm air rises and cooler air from the sea moves in to replace it. This is called a sea breeze as it originates from the sea.



Land breezes occur during the latter part of the night when the land has cooled. The cool, dense air above the land flows out to sea, displacing the relatively warm air over the sea

Land and sea breezes will only be found in the absence of gradient winds.

3.3 The Beaufort Scale

Beaufort number	Wind speed		Description	Wave height	Sea conditions	Land conditions
	Knots	Km/h				
0	0	0	Calm	0	Flat	Smoke rises vertically
1	1-3	1-6	Light air	0.1 m	Ripples without crests	Wind motion visible in smoke
2	4-6	7-11	Light breeze	0.2 m	Small wavelets with crests, not breaking	Wind felt on exposed skin and leaves rustle
3	7-10	12-19	Gentle breeze	0.6 m	Large wavelets with scattered white caps	Leaves and twigs in constant motion
4	11-15	20-29	Moderate breeze	1 m	Small waves	Dust and loose paper blows around. Small branches move
5	16-21	30-39	Fresh breeze	2 m	Moderate waves, some foam and spray	Small trees sway
6	22-27	40-50	Strong breeze	3 m	Large waves with foam crests and some spray	Large branches in motion and whistling heard in overhead wires.
7	28.33	51-62	Near gale	4 m	Sea heaps up and foam begins to streak	Whole trees sway and it becomes difficult to walk against the wind
8	34-40	63-75	Fresh gale	5.5m	Moderately high waves with breaking crest. Streaks of foam	Twigs broken from trees and cars veer on the road
9	41-47	76-87	Strong gale	7	High waves with dense foam. Wave crests roll over	Light damage to structures
10	48-55	88-102	Storm	9	Reduced visibility, very high waves and white surface	Trees uprooted and considerable damage to structures
11	56-63	103-119	Violent storm	11.5	Exceptionally high waves	Widespread structural damage
12	64-80	>120	Hurricane	>14	Huge waves with driving spray. Minimal visibility	Considerable, widespread damage

Table 1: Beaufort scale

4 Storms

Highveld weather changes very quickly especially in summer and violent storms can suddenly build up with hail and lightning. Bad weather is usually accompanied by poor visibility and a very choppy wave action which can make for a very uncomfortable and dangerous journey.

The appearance of cumuli-nimbus clouds in the south west usually heralds the build-up of Highveld storms. The wind will start to blow towards the building storm and the clouds will grow and darken. The approach of the storm will be signalled by thunder and lightning flashes and the wind will reverse. The thunderheads can rise up for thousands of meters into the sky creating updrafts which suck up the water droplets. These freeze and stick together to form hail when they reach the cold upper air and fall to earth as their mass increases.

5 Fog

Fog is a result of too much water vapour in the air. The air can only hold a certain amount of water vapour at a particular temperature and pressure. The higher the temperature and/or pressure, the more vapour the air can hold. Fog is formed when the temperature drops enough to condense the vapour in the air, usually due to the warm air being cooler rapidly as it passes over dams, rivers, swamps or the sea.

Radiation or land based fog will generally form during the night and burn off under the sun. Advection fog is normally formed over the sea and can be quite persistent.

6 Synoptic Chart

Synoptic chart is a weather chart reflecting the state of the atmosphere over a large area at a given moment. The chart is generated by acquiring a huge number of readings from ships, sea based automatic weather buoys and land based weather stations. The numbers indicate the barometric pressure and bigger numbers represent greater pressure. These data points are then processed using complex mathematics to 'best guess' or 'interpolate' values for areas where no reading was available. The meteorologist then draws lines connecting areas of equal pressure (called isobars), draws an H in the middle of any Highs, and an L in the middle of any Lows. The closer the isobars are together, the steeper the pressure gradient.

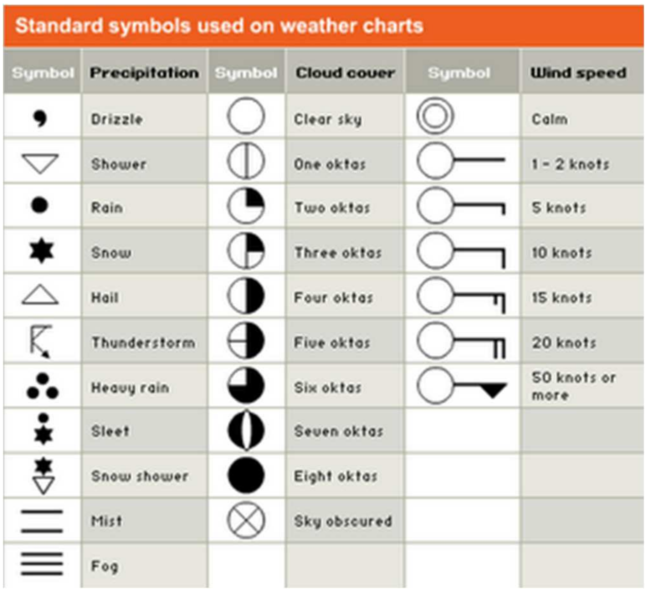


Figure 2: Synoptic chart symbols

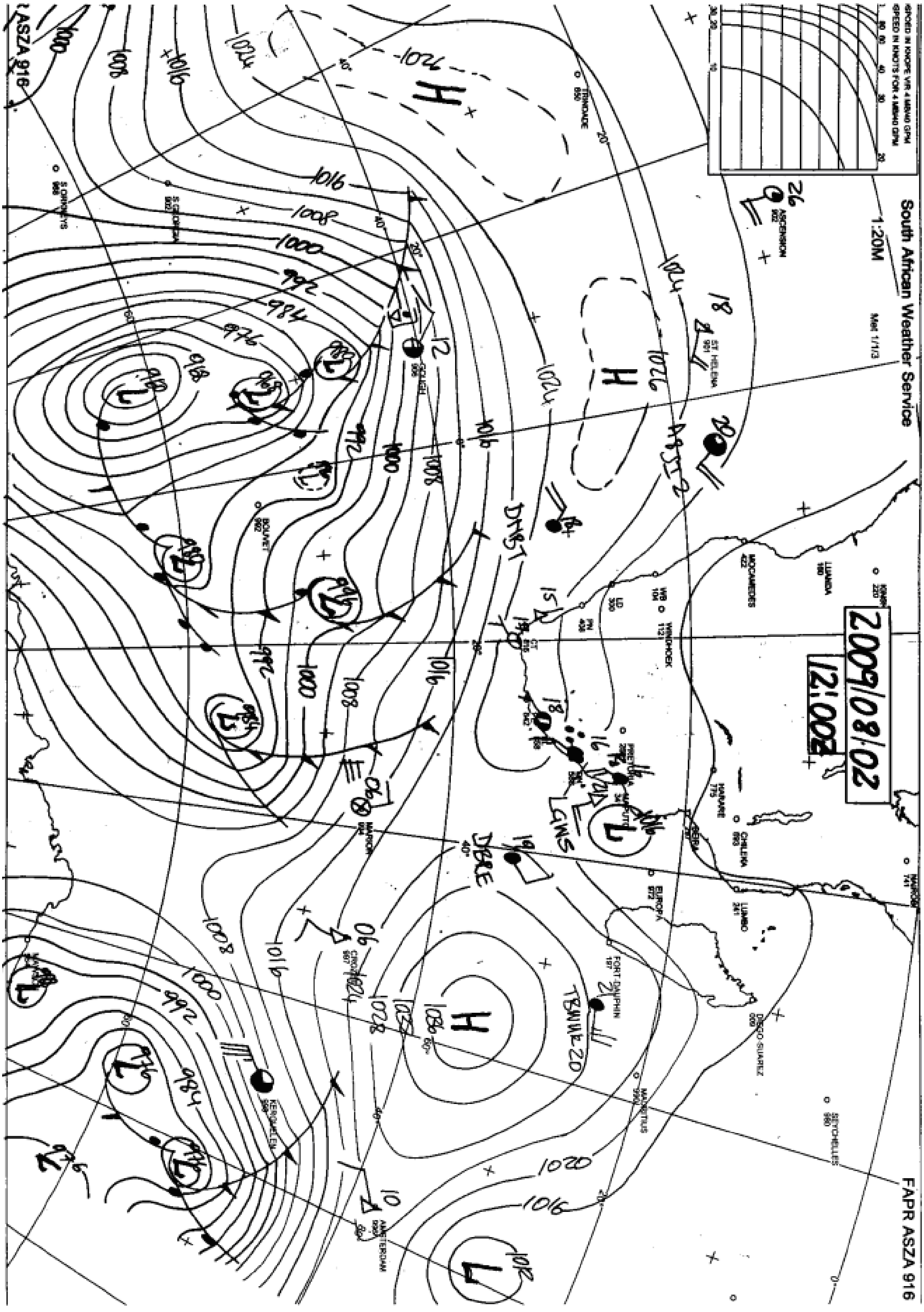


Figure 3: South African Synoptic Chart

Another common feature on synoptic charts is frontal lines. When two air masses of different temperatures meet, they do not readily mix. This results in the formation of a boundary line between the two air masses, known as a front

The most common and noticeable type of front is the cold front. As this cold air meets warmer air, the warm air is forced upwards. The rising air condenses to form a squall line at the front of the 'front'. Cold fronts are associated with a rapid drop in temperature and high winds. Because the winds travel clockwise around a low pressure system, the first taste you get is Northerly, but more often than not North Westerly. As the cold front passes through these winds rotate around the compass, going from NW to W to SW, and maybe S.

Often the low at the centre of a cold front will be drawn with an associated warm front. As the cold air moves NE, the warm air is forced SE

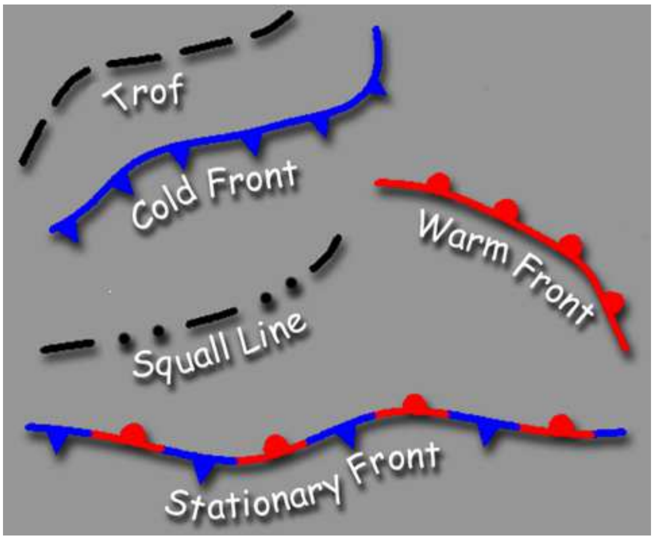


Figure 4: Types of fronts

7 Wave action

Waves are formed by wind blowing across water. Very simply put, the calmer the wind the calmer the water. The wind drags the water forward to form waves which slowly move in the direction of the wind and get larger.

The height of a wave depends upon three factors;

- How hard the wind is blowing.
- How long the wind has been blowing.
- The fetch. (The length of the stretch of open water over which the wind is blowing.)

There is little actual forward motion of individual water particles in a wave, despite the large amount of energy it may carry forward.

In a wave, water travels in loops. But since surface is the area affected the diameter of the loops decreases with depth. The diameters of loops at the surface is equal to wave height (h)

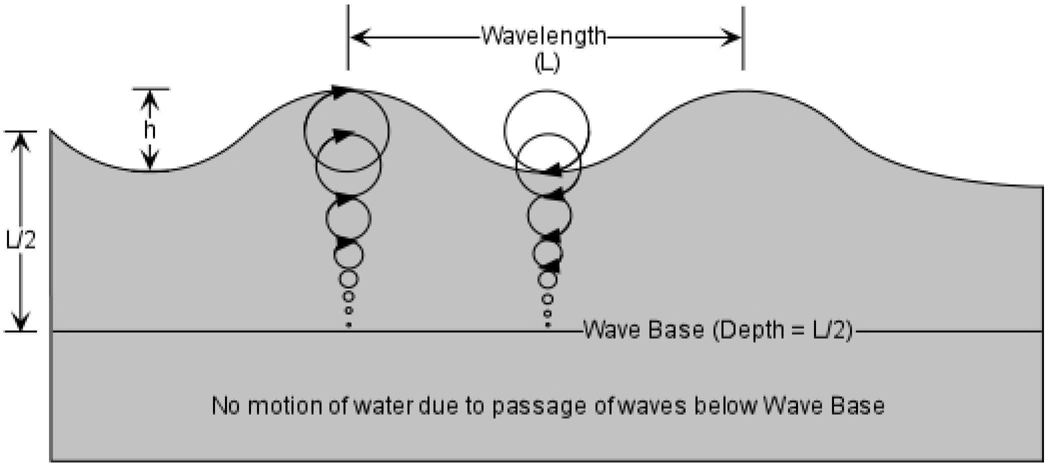


Figure 5: Wave motion

- Wavelength (L) = distance to complete one cycle
- Wave Period (P) = time required to complete on cycle.
- Wave Velocity (V) = wavelength/wave period (L/P).

Motion of waves is only effective at moving water to depth equal to one half of the Wavelength (L/2). Water deeper than L/2 does not move.

When waves approach shore, the water depth decreases and the wave will start feeling bottom. Because of friction, the wave velocity (= L/P) decreases, but its period (P) remains the same Thus, the wavelength (L) will decrease. As the wavelength (L) shortens, the wave height (h) increases. Eventually the steep front portion of wave cannot support the water as the rear part moves over, and the wave breaks. This results in turbulent water where incoming waves meet back flowing water.

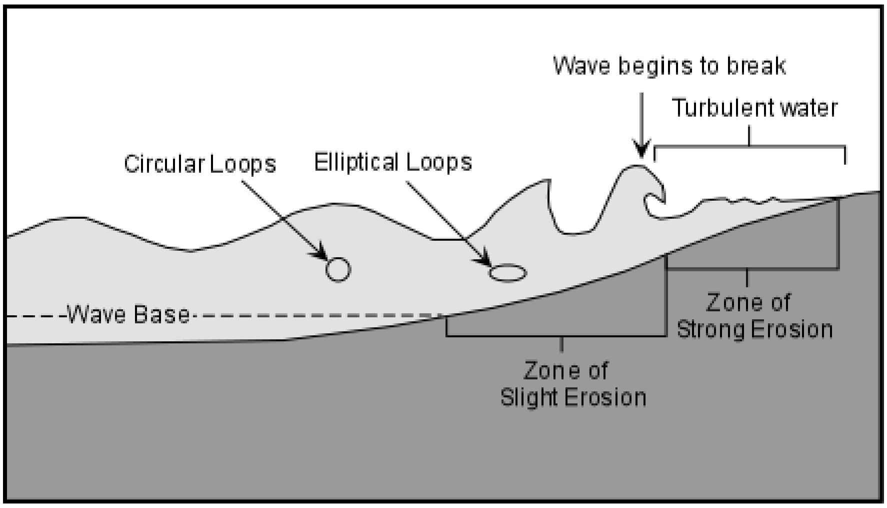


Figure 6: Wave action

Another cause of turbulent and choppy water is wave "bounce", the "bounce" is caused by the onshore waves striking the shore and "bouncing" back to meet the next oncoming wave. This is especially evident in deep water off a steep shoreline or cliff.

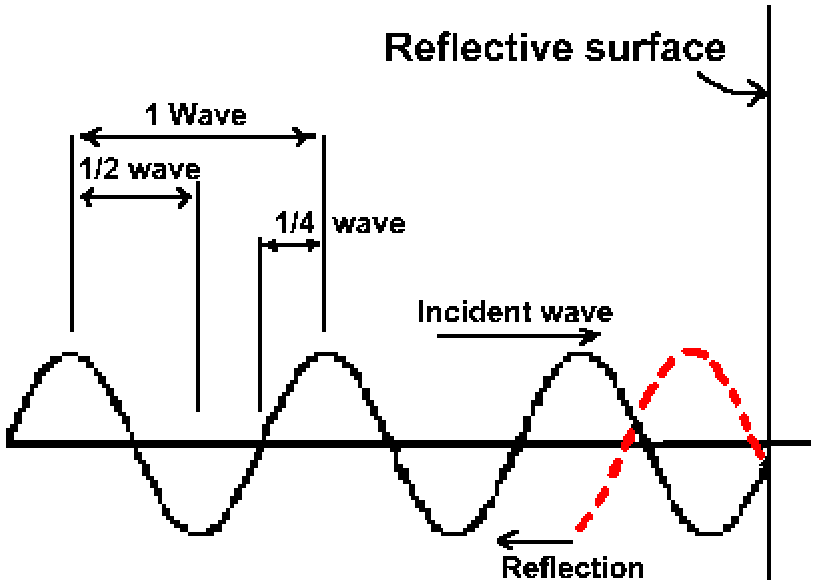


Figure 7: Reflection of waves

Waves will continue moving across the water until they strike an obstruction such as a breakwater or the shore. Residual waves can remain after the wind has died and these will become smaller and smaller until fully calm unless a new wind blows which will again cause the waves to rise.

One of the characteristics of our large dams is that the wind often has sudden changes of direction. This is caused by interference from hills, tree lines and the swirling action of the wind in a typical Highveld storm. A change of wind direction, especially a 180 degree turn will cause waves to rise up and start to break as the wind is now blowing against the waves.

8 Dams

For some years, it has been common knowledge that large dams lead to an increase in rainfall and severe storms. This has now been the subject of an academic study

Researchers at Tennessee Tech University, Purdue University, the University of Colorado and the University of Georgia have published a study concluding that artificial reservoirs can modify precipitation patterns. The study—published in Geophysical Research Letters—marks the first time researchers have documented large dams having a clear, strong influence on the climate around artificial reservoirs

The large surface area of the dam's reservoir exacerbated by the nearby use of the water, such as extensive irrigation or recreational activities, creates an altered climate because it allows the water to evaporate more easily. Such an increase in water available for evaporation can change humidity, temperature and other aspects of the climate system around a reservoir. Under the right circumstances, all of these play an important role in changing rainfall.

The Vaal Dam is a prime example of this phenomenon. Generally shallow, with a surface area of over 300 km^2, evaporation losses are substantial. This leads to the build-up of afternoon thunderstorms which can be quite severe.