

ENV101 - EARTH SYSTEMS

THE HYDROSPHERE AND THE WATER CYCLE
Presented By Ian Lancaster
KSI Land and Water Planning

EARTH SYSTEMS

Climatic Processes · Hydrologic Cycle · Biogeochemical Cycles

Before talking about the water cycle there are some things we need to review.

Remember that water is made up of molecules of oxygen and hydrogen atoms, H_2O that are always moving.

And how fast these molecules are moving determines whether the water will be a solid, a liquid, or a gas.

And just how fast these molecules move is determined by heat energy, how hot or how cold they are.

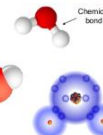
WATER CHEMISTRY

Chemical Formula

- H_2O
- Shows how many and which type of atoms make a single molecule



- How many atoms form one water molecule?



•Of course, molecules are way too small to be seen. But if you can visualize the molecules as small balls, molecules of water in the three states of matter might appear something like this:

Solid



Liquid



Gas



•We will first look at our model of solid water called "ice." The molecules are tightly packed and vibrating in place.

•When there is only a small amount of heat energy the molecules are packed so tightly together that they form ice.

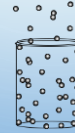
• At sea level, water is transformed into ice, or frozen, at 0 degrees Celsius. This is the solid form.



- Next, we have our model of liquid water molecules.
- When there is more heat energy, the molecules move about more vigorously within their container.
- At sea level the liquid form can range between 0 and 100 degrees.



- Finally, we have our model of molecules of gaseous water called "water vapor."
- There is even more heat energy now, and the molecules are moving rapidly, banging on the walls of whatever container they are in, escaping where ever there is an opening.

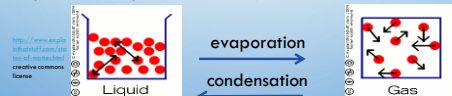


- The important thing is that the amount of heat energy determines whether our H_2O molecules are a solid, liquid or gas.
- Adding or subtracting heat energy can cause water to change from one phase, like ice or liquid or gas, to another.
- Water vapor is water in the form of a gas.
- Like most gases, water vapor is invisible.
- Even though we cannot see them, air always contains molecules of water vapor mixed in with molecules of nitrogen, oxygen, argon and carbon dioxide.
- Having learned that there is always some water vapor found in air, we should also understand that:
- The warmer the air the more water vapor molecules there are.
- The cooler the air the fewer water vapor molecules there are.

Water molecules in air do not remain in one state of matter or another; they are constantly changing back and forth between stages.

Stage changes between vapor, liquid and solid happen because of temperature changes.

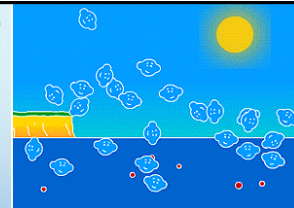
When liquid water molecules gain heat energy they become water vapor (evaporation): when water vapor molecules lose heat energy they become a liquid (condensation).



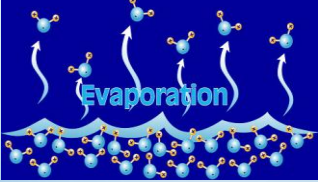
Now let's look at the water cycle. Although the water cycle is like a circle that has no beginning or end, we will start our study with:

evaporation.

Water on the Earth's surface is continually evaporating—changing from a liquid to the gas called water vapor.



Even on a cool, dull day the energy from the Sun heats the surface of the sea causing some of the water to change from a liquid into water vapor. This process is called **EVAPORATION**.




Here we see a diagram of some liquid water molecules gaining enough heat energy from the sun to change into molecules of water vapor.

However, remember:


1. Water molecules are too small to see without a microscope
2. Water vapor is invisible

Nearly 90% of the the water vapor in our atmosphere comes from the oceans, seas and other bodies of water (lakes, rivers, streams) through evaporation.



We know that water is evaporating from the water shown above but we cannot see it. Water vapor is invisible.

The remaining 10% of the moisture found in the atmosphere is released by plants through transpiration—release of water vapor from leaves.



While most of the water vapor for the water cycle comes from evaporation, transpiration adds a lot of water vapor. For example, a cornfield 1 hectare in size can transpire as much as 40 kilolitres of water every day.

Now that we understand that there is water vapor in the air, the next step to be examined in the water cycle is:

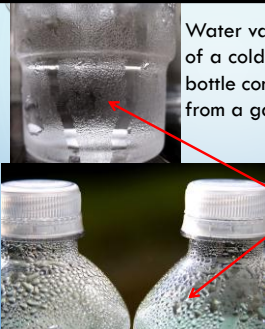
Condensation

Clouds form as the result of condensation—water vapor that is cooled changes to liquid water.

This process of condensation is constantly occurring all around us as water vapor molecules in the air bump into cool surfaces.


Because when water vapor molecules strike a cooler surface, they slow down and sometimes change into tiny droplets of liquid water that look like “fog”.

Over time, these tiny droplets of water join together forming larger and larger drops.




Water vapor hitting the sides of a cold glass or water bottle condenses (changes from a gas to a liquid).

condensation




As time passes the water droplets increase in size.




More condensation

Water vapor condensing on a cold window.



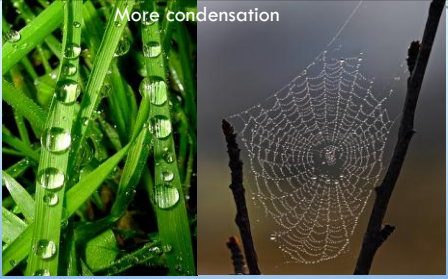
More condensation

Water vapor condensing on a cold mirror.




More condensation

Water vapor condensing on the cold car windshield.



More condensation

Water vapor condensing on grass or a spider web--dew.




More condensation

Like the "fog" on the window or mirror, steam is made up of tiny water droplets.

Steam is **not** water vapor.

When the water vapor from the boiling water hits the cooler air outside the tea kettle, it condenses as tiny water droplets.

More condensation

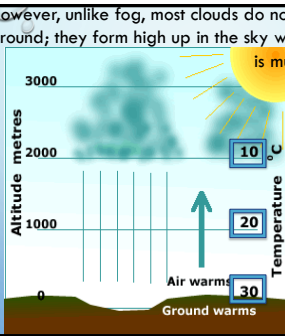


At night sometimes, water vapor condenses as it comes in contact with the cool ground creating fog—a cloud on the ground.




Bridge peeking above the fog on the ground.

However, unlike fog, most clouds do not form on the ground; they form high up in the sky where the air is much cooler.



As you move up in the atmosphere it becomes colder and colder.

Clouds—another product of condensation. As water vapor is cooled high in the atmosphere it condenses into tiny water droplets—a cloud.



Here we see pictures of clouds high up in the sky.

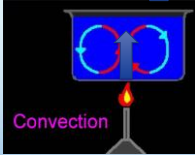
Now we have to ask what causes this warm air that is loaded with water vapor to rise ?

Usually this “lifting” of warm air is caused by another of our “cycles.”

Convection

The tendency of hotter and therefore lighter (molecules further apart) liquids and gases to rise, and for colder, heavier (molecules closer together) liquids and gases to sink.

under the influence of gravity.



colder, denser (heavier) material sinks

Convection

hotter and therefore less dense (lighter) material rises

colder, denser (heavier) material sinks

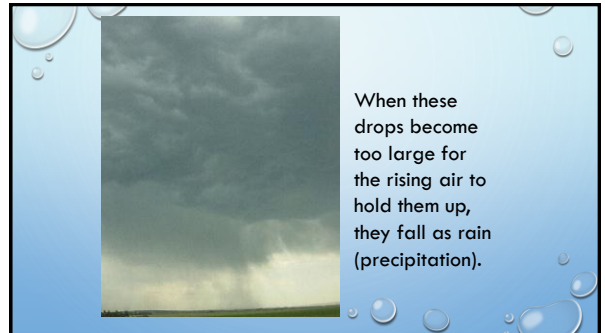


However, as the tiny droplets inside the cloud collide, they join and droplets grow in size.

Finally water drops form.

Which brings us to the next part of the water cycle,

Precipitation.

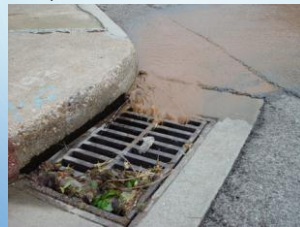


Getting this fallen water (precipitation) back to the rivers, lakes and oceans is also part of the water cycle. Water can take two paths back to larger bodies, one is on the **surface** and the other is **underground**.

Some precipitation that falls on the ground flows over the land to streams and rivers and finally to the ocean.

This is called **surface run off**.

You can easily observe this surface run-off if it is water running down your driveway, along the curb of your street and into a storm sewer.



During a heavy rain, water flows over the soil filling creeks which then flow into streams and finally into rivers. The surface runoff that flows into a creek is beginning its journey back to the ocean.

BREAK AND QUESTIONS

The hydrosphere

Blue Planet (2006)2
<https://photos.state.gov/libraries/ohio/6462>

Total water on Earth

- sea water 97 %
- fresh water 3 %

Total fresh water

- ice 68.7%
- groundwater 30.1%
- surface water (liquid) 0.3%
- other 0.9%

Total surface fresh water (liquid)

- lakes 87 %
- swamps 11%
- rivers 2%

Origin of the hydrosphere

Primitive atmosphere:

- carbon dioxide
- water vapour

condensation

Temperature

gaseous water

liquid water

solid water

4,500 million years ago

Present

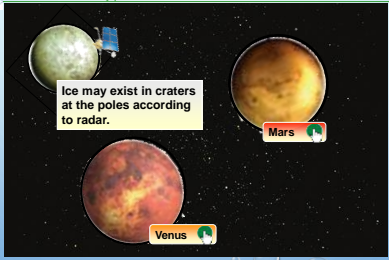
Water on other rocky planets

Mercury

Mars

Venus

Water on other rocky planets



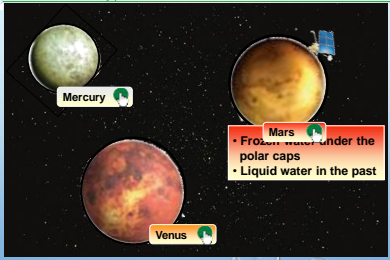
Ice may exist in craters at the poles according to radar.

Mercury

Venus

Mars

Water on other rocky planets



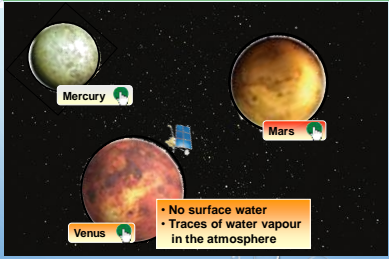
Mercury

Venus

Mars

- Frozen water under the polar caps
- Liquid water in the past

Water on other rocky planets



Mercury

Venus

Mars


- No surface water
- Traces of water vapour in the atmosphere

What are some properties of water?



- It is an excellent solvent.
- It expands on freezing.
- It absorbs a lot of heat.
- It is highly cohesive and adhesive.

Natural disasters produced by water



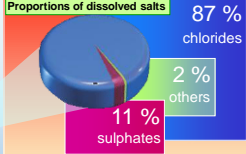
Flash flooding

River flooding

Torrential rain

Tsunamis

What is sea water like?



Proportions of dissolved salts

- 87 % chlorides
- 11 % sulphates
- 2 % others

- It is salty.
- It contains dissolved gases from:
 - wave action
 - the activity of aquatic plants and animals
- Temperature varies with depth.

Movements produced in the oceans

Waves are caused by

Tides are caused by

Ocean currents are caused by

Movements produced in the oceans

The wind

Waves are caused by

Tides are caused by

Ocean currents are caused by

Movements produced in the oceans

Waves

Tides are caused by

Gravitational attraction of the Moon and Sun on the water

Ocean currents are caused by

Movements produced in the oceans

Waves are caused by

- Winds
- Differences in temperature
- Differences in salinity

Tides are caused by

Ocean currents are caused by

Where is fresh water found?

Lakes

Rivers

Streams or Creeks

Groundwater

Wetlands

Glaciers

WATER CYCLE REVIEW

Danish Sailing Club - 8.3m Kite

Waterfall with - 1486442

Danish Harbour

07.25.2012

Lower Edge of Clouds - the Clouds

10.28.2012

What is the water cycle?

Labels in the diagram: water storage in ice and snow, condensation in the form of clouds, precipitation, infiltration, surface runoff, evaporation, evapotranspiration.

Surface Runoff

- Water flows over the ground instead of sinking into the ground
 - Snow melts, rain runs off surfaces, etc.
 - Streams and rivers carry water back to oceans

What is the water cycle?

Labels in the diagram: permeable rock, groundwater, water storage in ice and snow, condensation in the form of clouds, precipitation, infiltration, surface runoff, evaporation, evapotranspiration.

Groundwater

- Precipitation seeps down through soil & rock
- Layers act as filters that trap contaminants
- Water table:** imaginary line between the water-logged soil and the soil not saturated with water
 - varies with seasonal precipitation, pumping, & geography
- Two types of aquifers:
 - unconfined:** water supply which has a solid layer of rock under it, but a permeable layer of rocks above it
 - confined:** water supply sandwiched between two solid rock layers through which water cannot pass
 - pressure builds up and can form an artesian well

What is the water cycle?

Labels in the diagram: water storage in ice and snow, condensation in the form of clouds, precipitation, infiltration, surface runoff, evaporation, evapotranspiration.

Infiltration

- Water absorbed into subsurface of dirt & rocks
 - Water percolates down between spaces in soil
 - Groundwater** empties into streams/rivers/oceans or is stored underground in aquifers
- Saturation** = all the spaces in soil & rock are filled with water
 - Flooding occurs:
 - when soil becomes saturated, or
 - when precipitation falls faster than infiltration can occur

What is the water cycle?

condensation in the form of clouds

precipitation

water storage in ice and snow

infiltration

surface runoff

evaporation

evapotranspiration

Hailstone formation

THE WATER CYCLE © 2008 National Science Foundation

NATIONAL WATER CYCLE BOARD

Precipitation

- Water falling from the atmosphere
 - Vapor molecules collide & join to form droplets
 - Falls as rain, snow, sleet, or hail

Transpiration

- Emission of water vapor from plants
 - Plants absorb water from soil to use in photosynthesis
 - Water vapor released through stomata (pores) under leaves

Water Resists Temperature Changes

- Heat = how fast molecules are moving
- Water's polarity makes the molecules both "sticky" and "slippery" (like magnets that attract & repel)
 - stickiness: resistant to vaporizing because of cohesion
 - slipperiness: resistant to freezing because they keep sliding around
- Specific Heat = energy needed to raise or lower 1g of anything by 1° C
 - Water has a very high specific heat
- Water stabilizes air temperatures
 - Absorbs/releases large amounts of heat with only a slight change in its own temperature

Water Vapor


- Water boils at 100°C (212°F)
 - LOTS of energy to break hydrogen bonds
- Evaporation can occur at much lower temperatures
- Water vapor in atmosphere resists temperature changes
- Evaporation absorbs lots of heat energy
 - Evaporative cooling (sweat, panting, seashore)

Adhesion

- Attraction between particles of different substances
 - i.e. water and glass
- Explains capillary action
 - water molecules will "climb" each other along when in a thin tube
- Transports water against gravity (roots to leaves) in plants

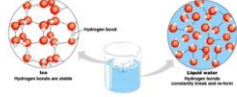
Cohesion

- Attraction between particles of the same substance (i.e. water molecules)
- Results in **Surface Tension**
 - molecules at the surface cling together
 - produces a "film" on top of water that allow some things to remain afloat
 - only at surface



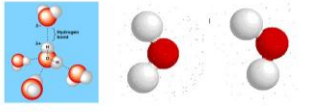
Frozen Water's Density

- Water freezes at 0° C (32° F)
- H₂O is most dense at 4° C (as a liquid)
- Crystal lattice formation the result of water's polarity
- Density of solid H₂O is 9% less than liquid H₂O



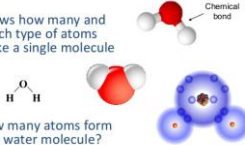
Hydrogen Bonding

- Attraction between oppositely charged regions of water molecules
- Each molecule can have H-bonds with four other water molecules
- Weak bonds continually break & reform




Chemical Formula

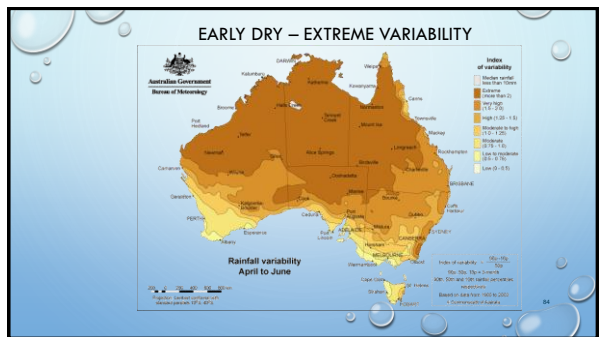
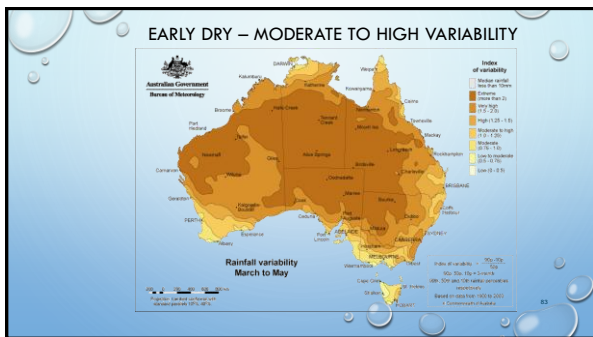
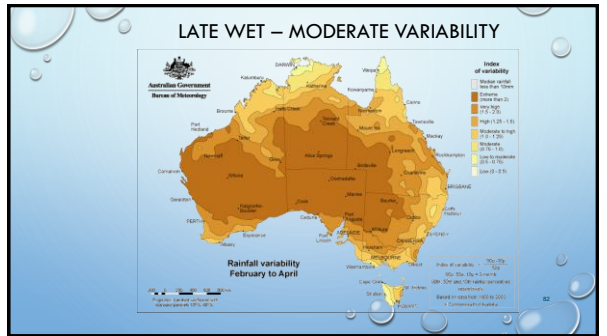
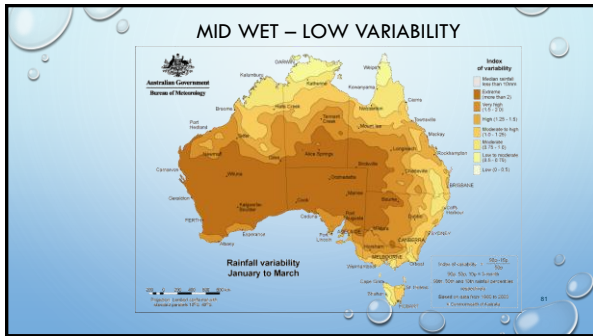
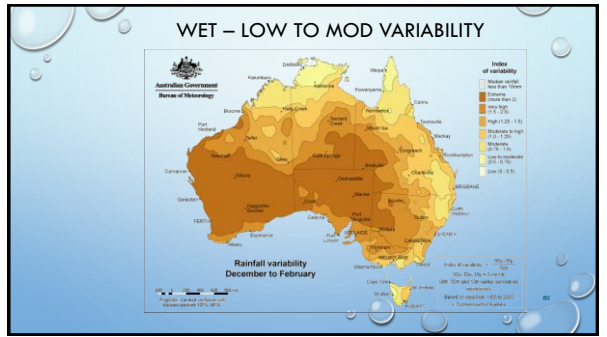
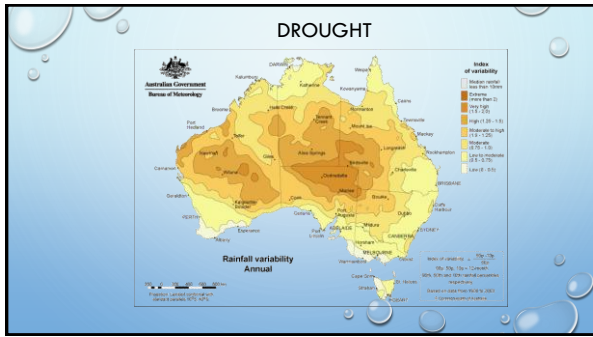
- H₂O
- Shows how many and which type of atoms make a single molecule
- How many atoms form one water molecule?

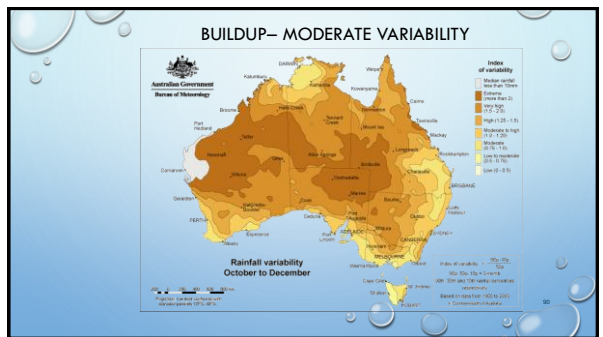
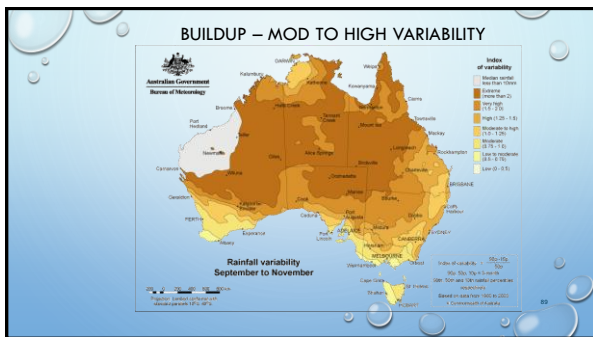
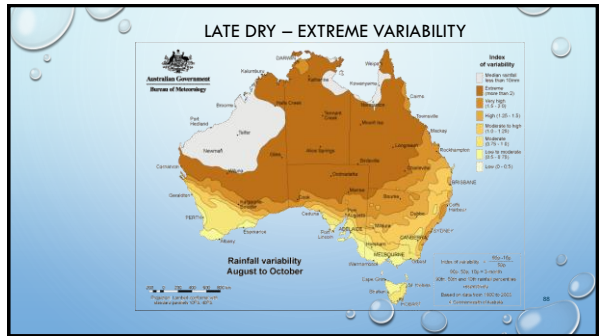
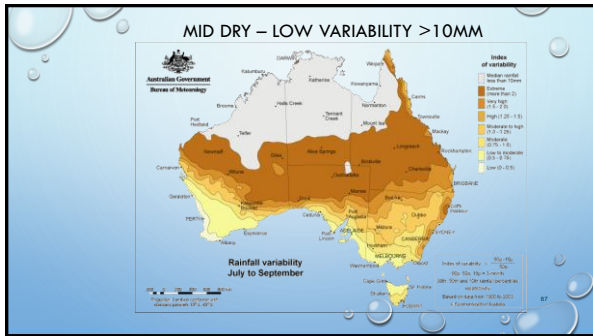
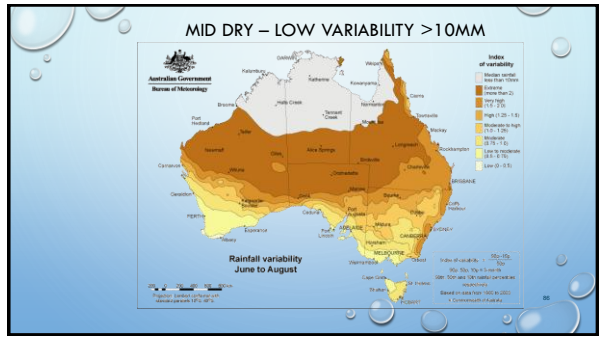
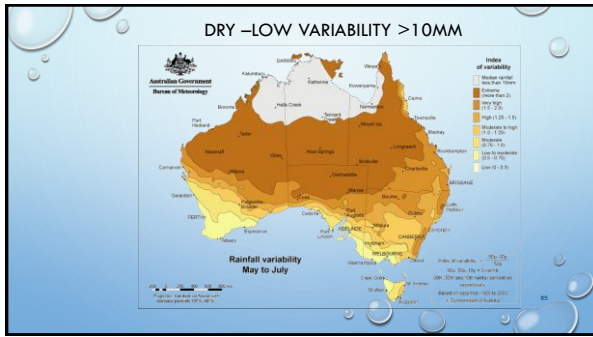


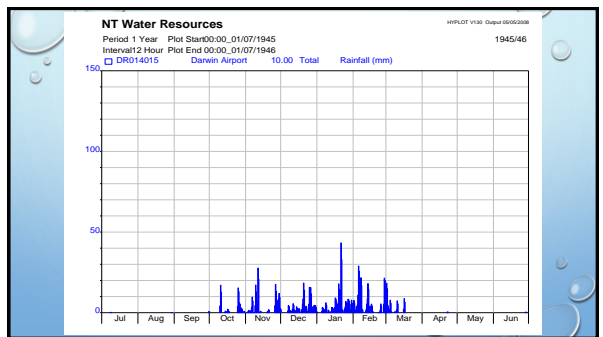
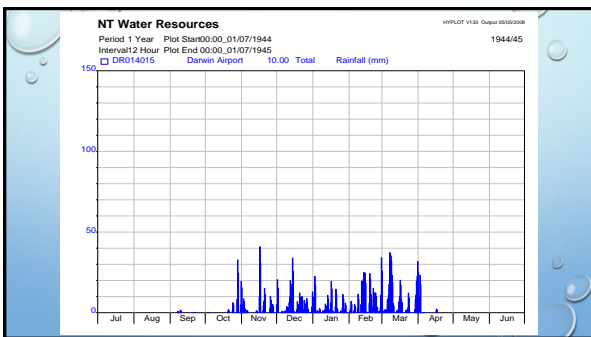
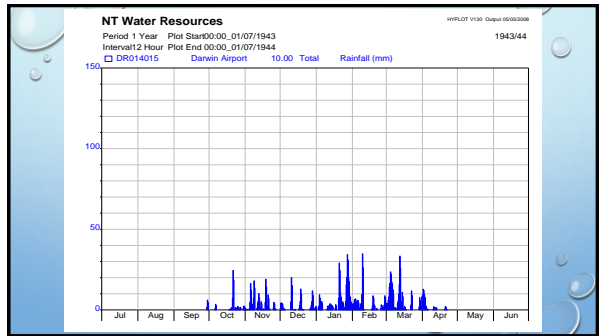
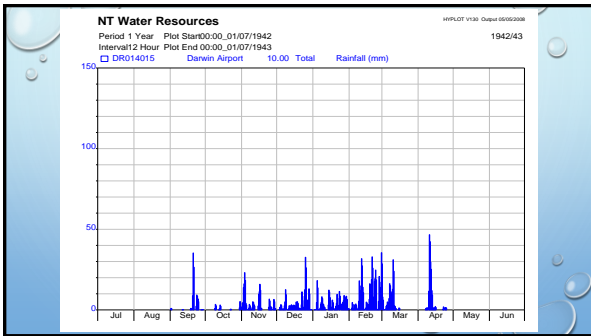
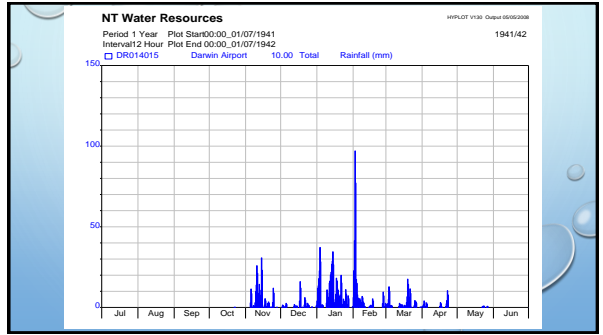
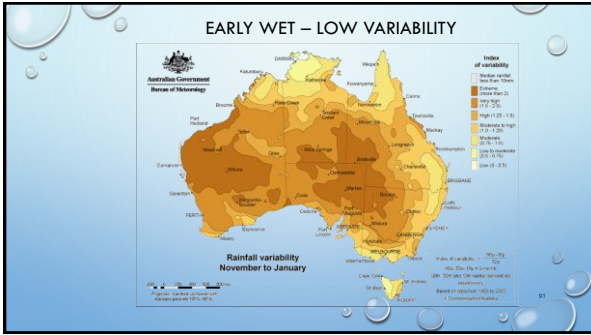
BREAK AND QUESTIONS

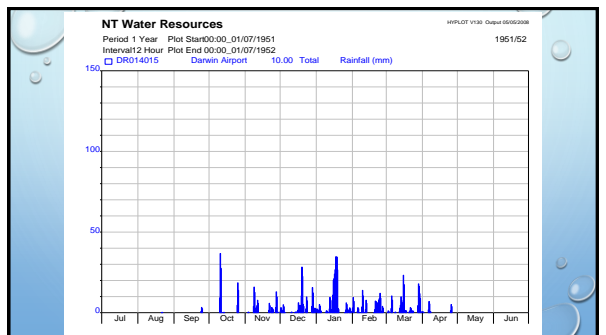
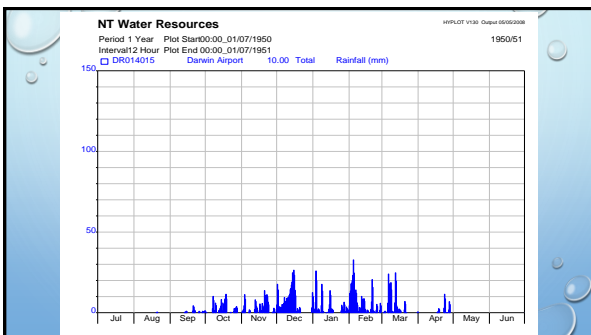
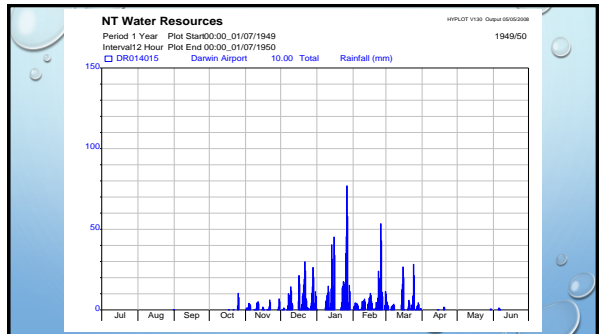
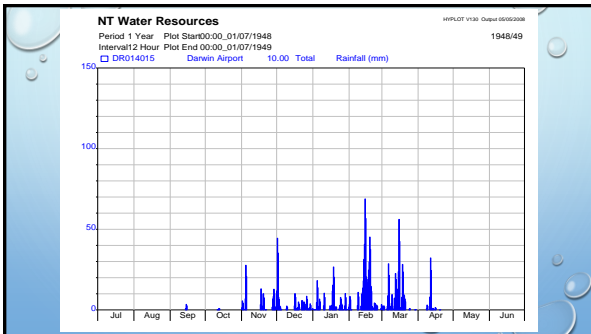
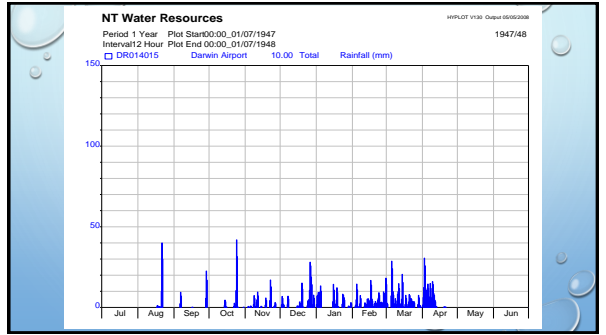
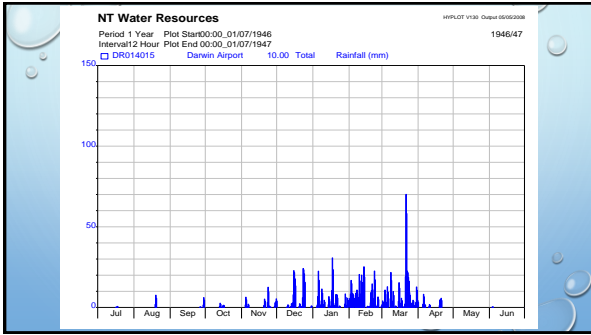
NT Water Resources – Constraints, Opportunities and Climate Change
Ian Lancaster

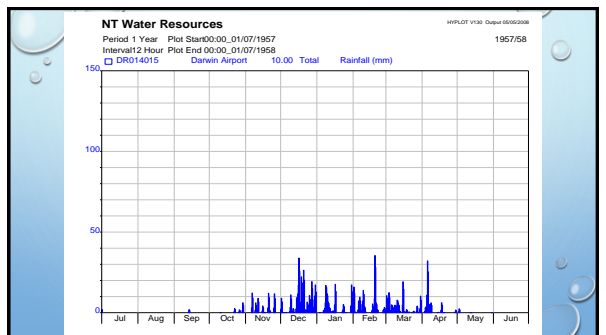
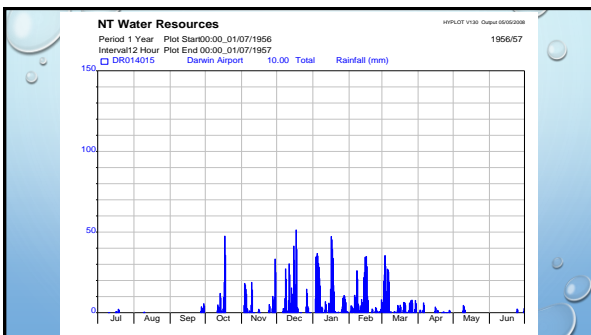
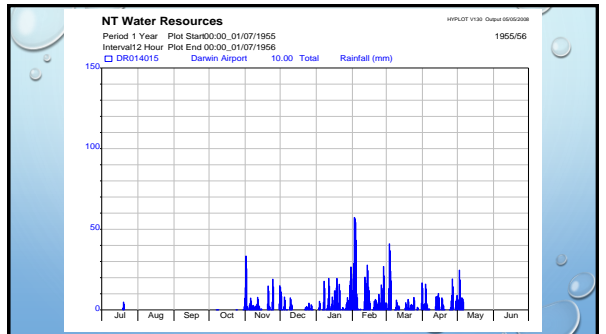
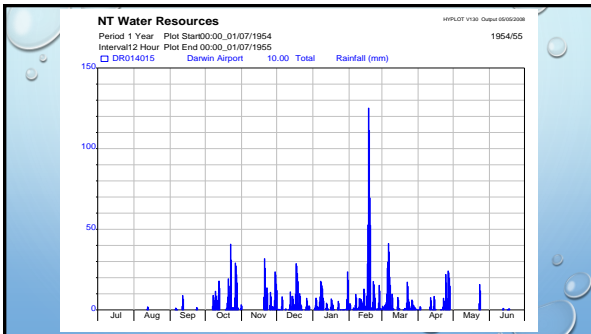
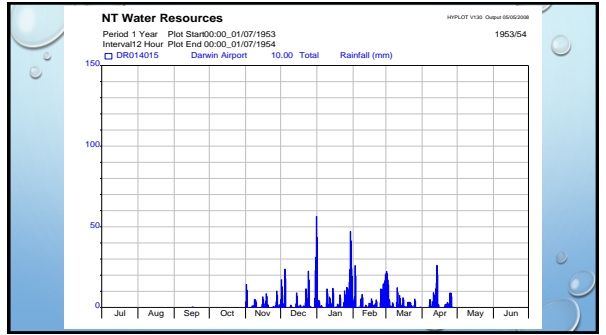
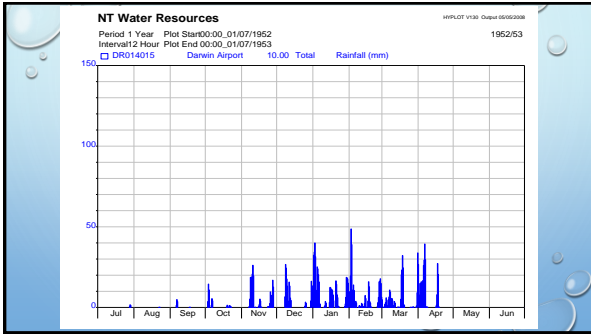


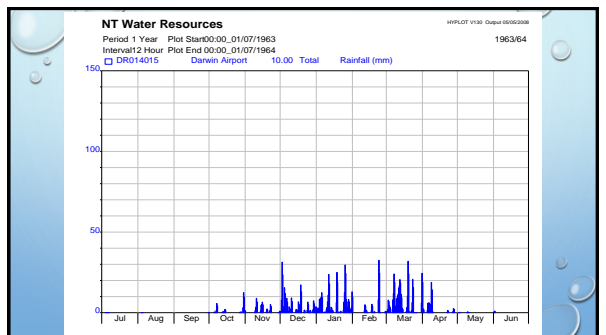
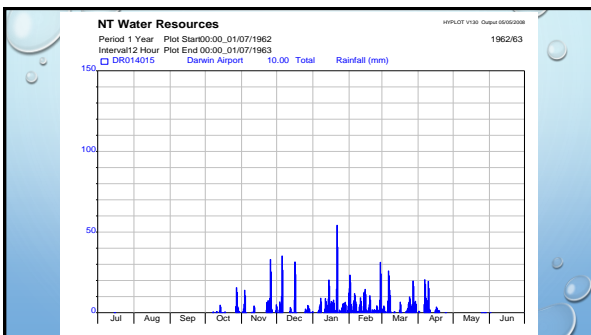
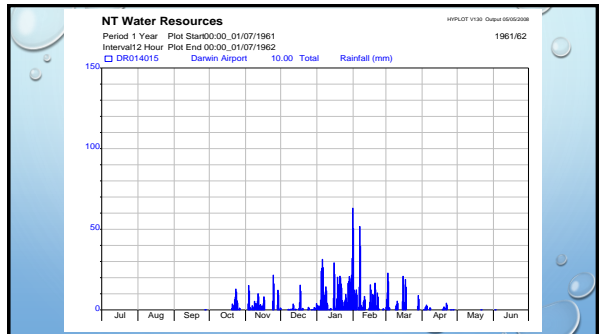
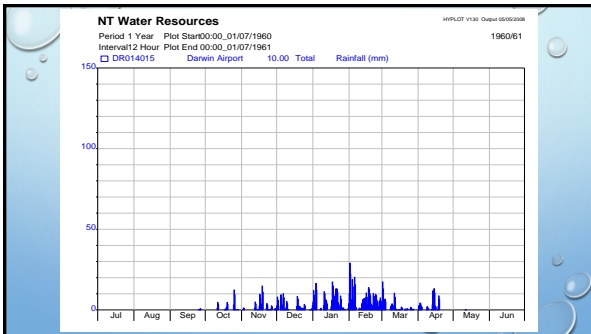
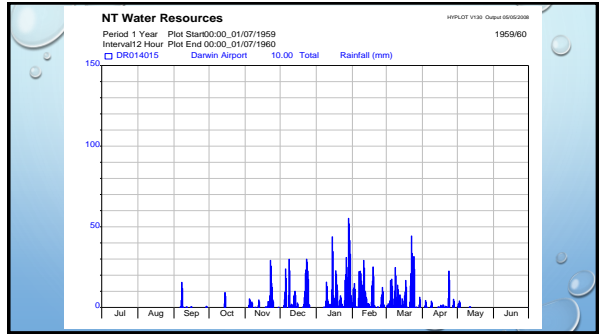
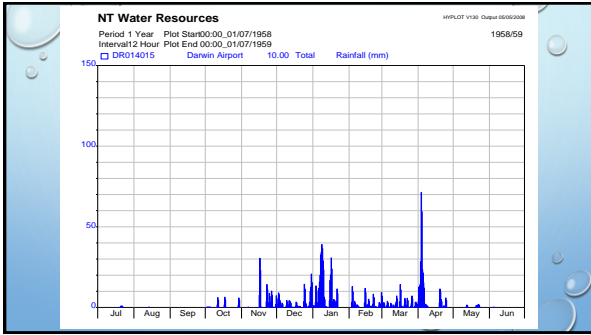


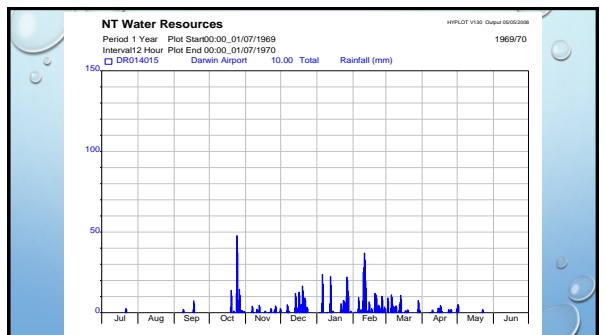
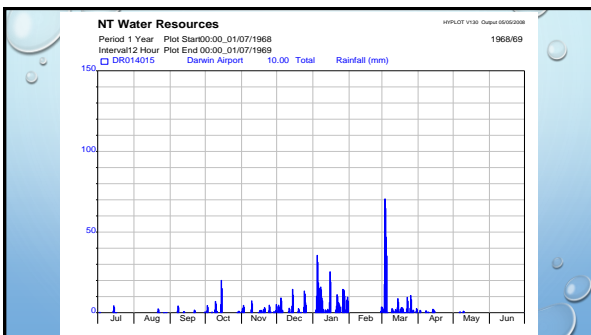
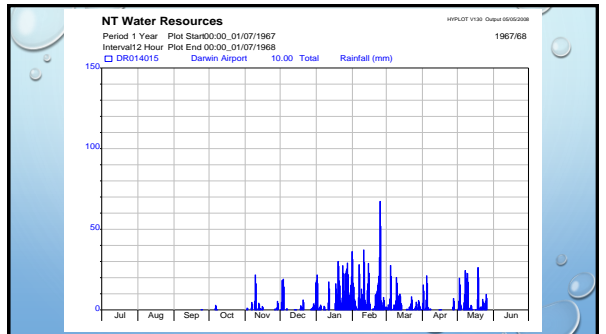
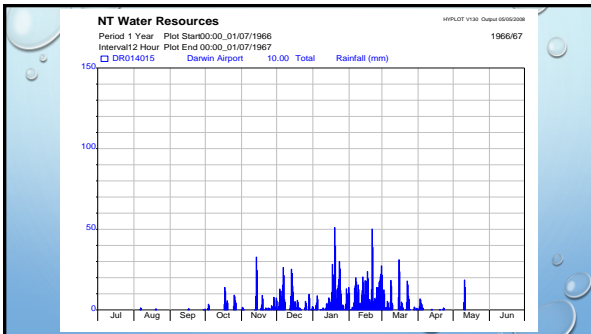
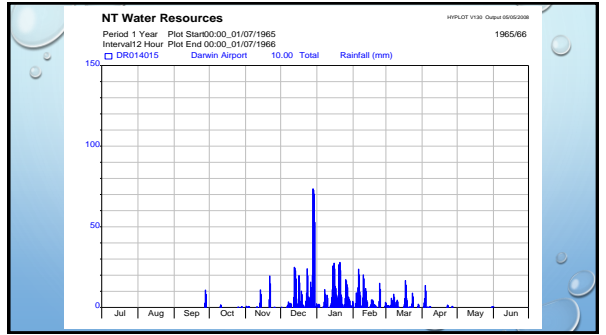
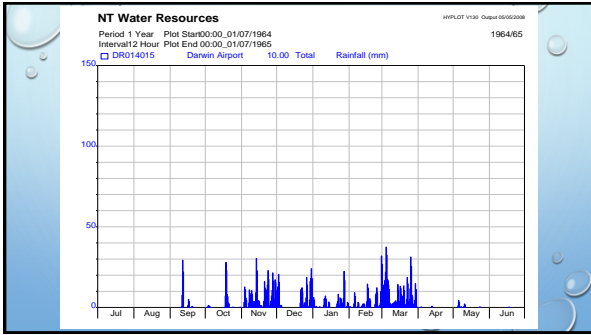


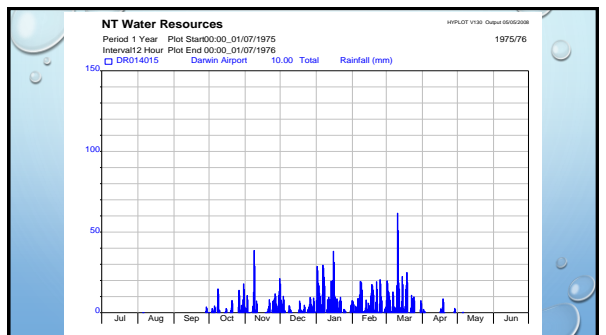
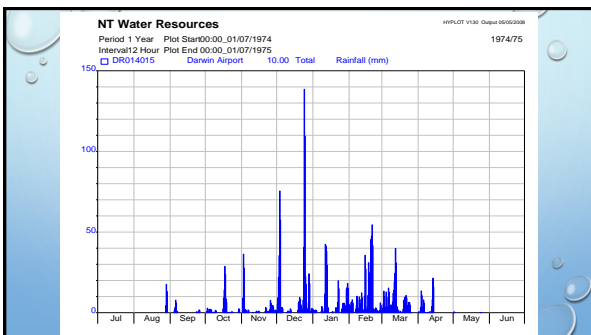
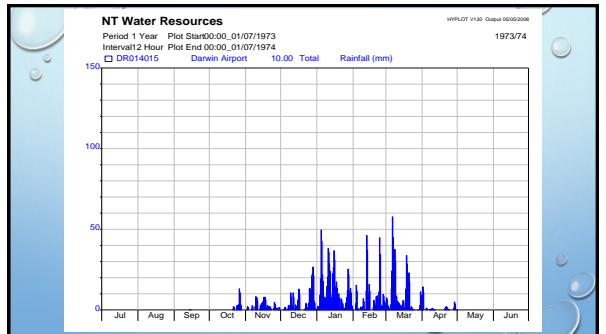
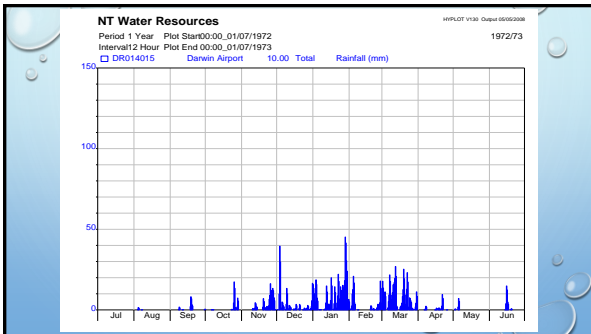
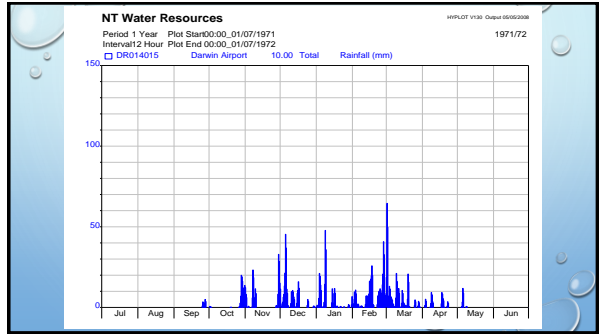
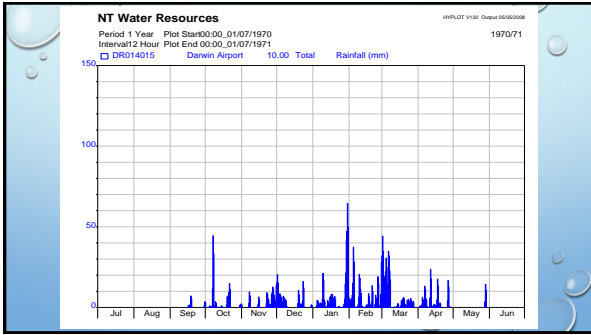


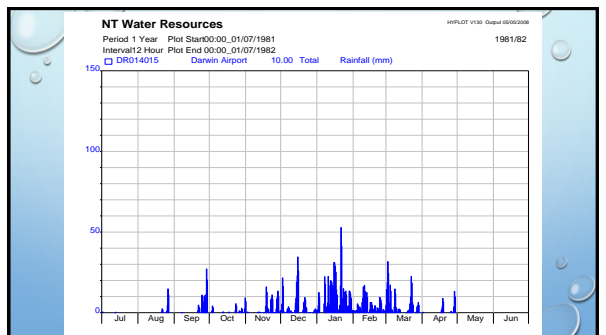
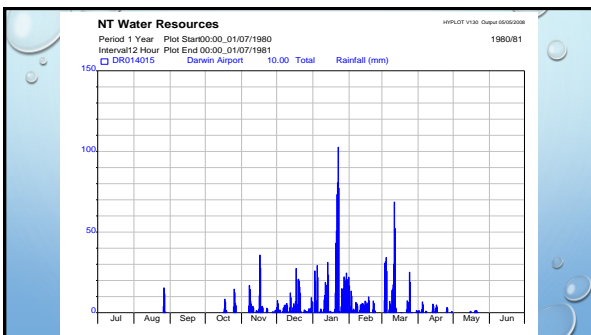
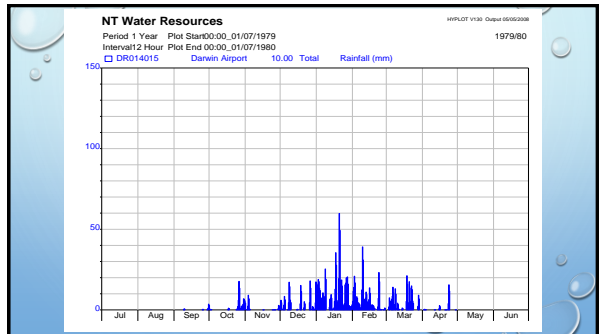
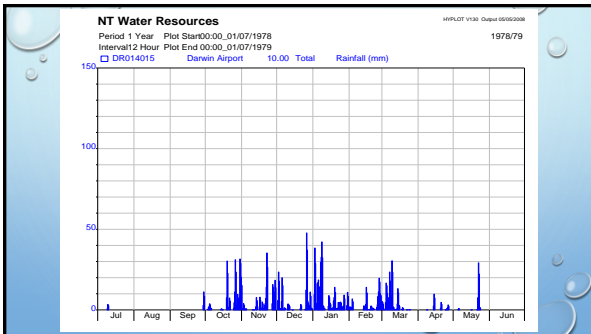
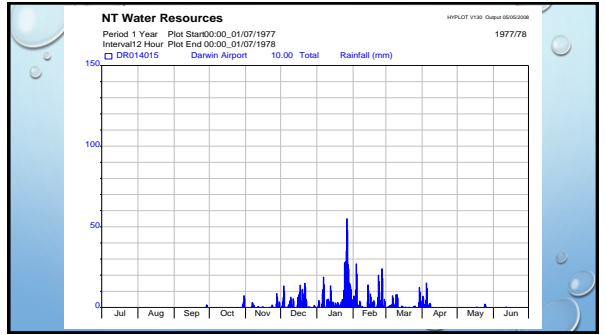
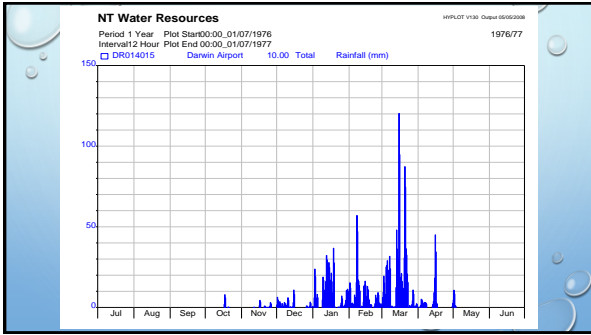


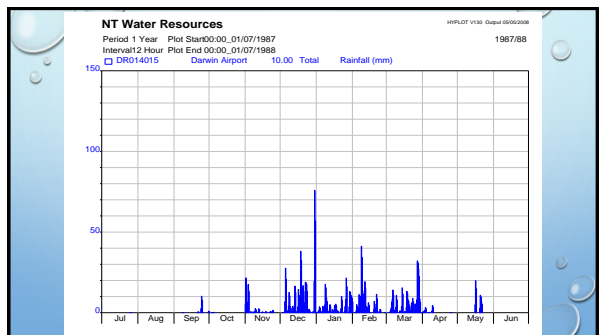
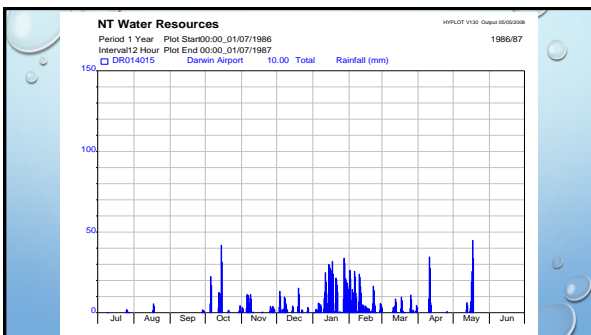
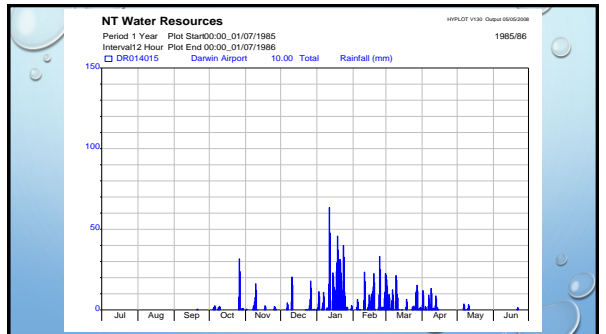
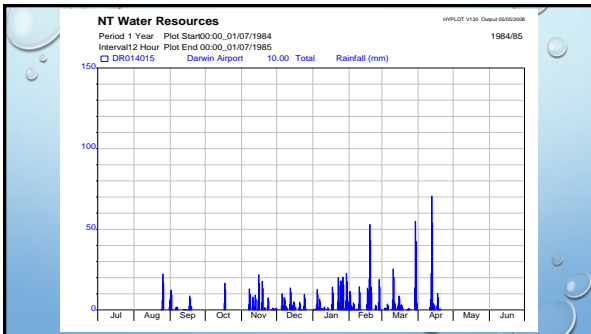
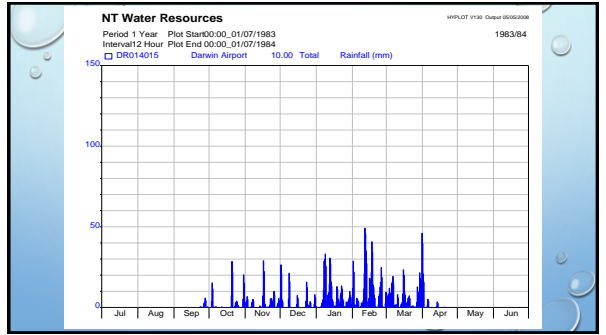
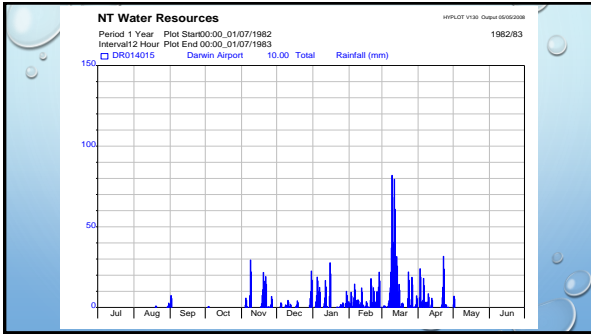


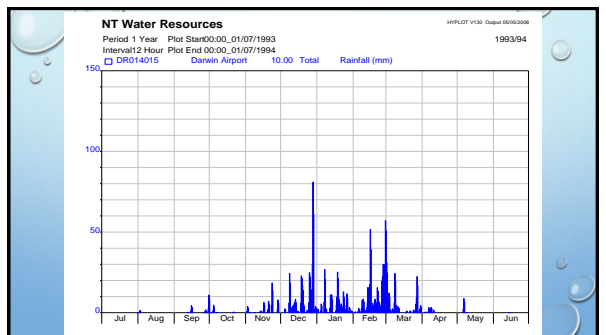
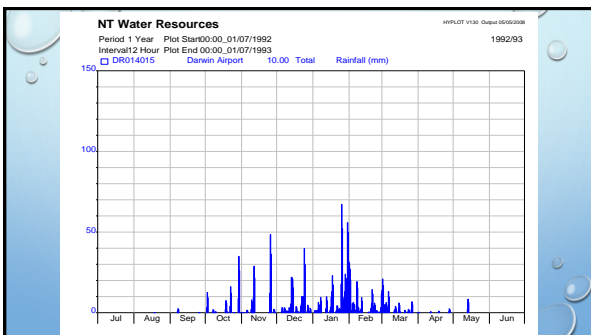
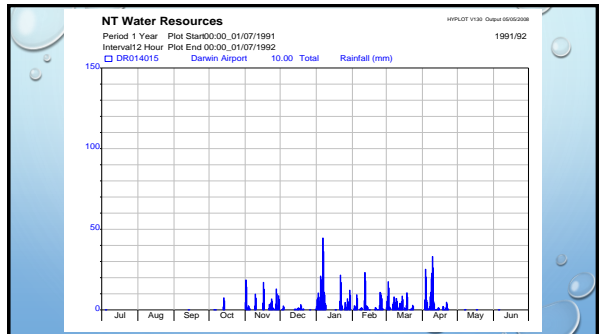
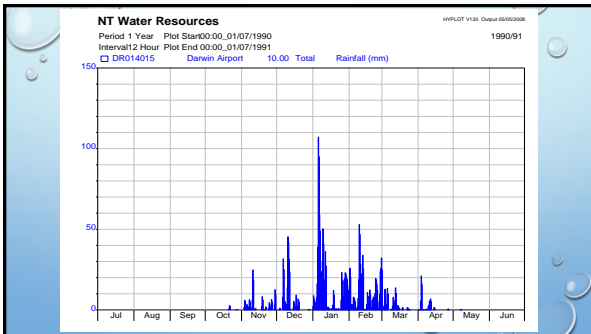
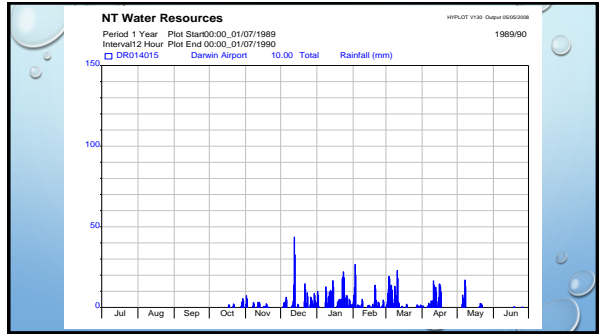
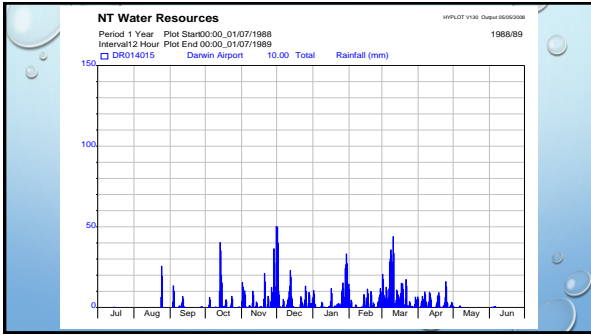


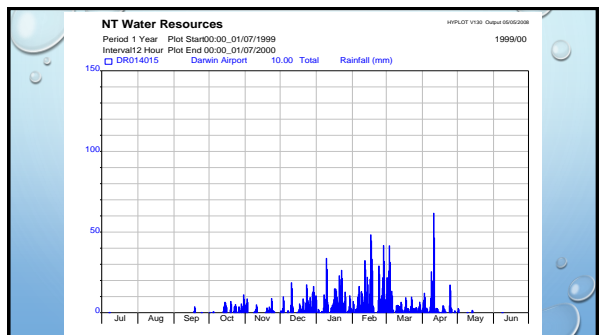
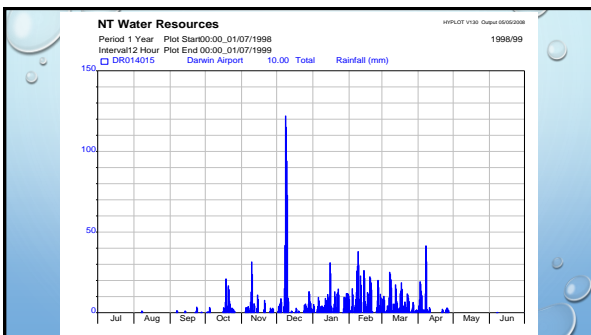
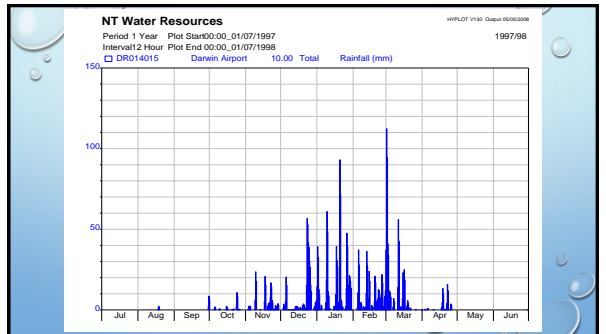
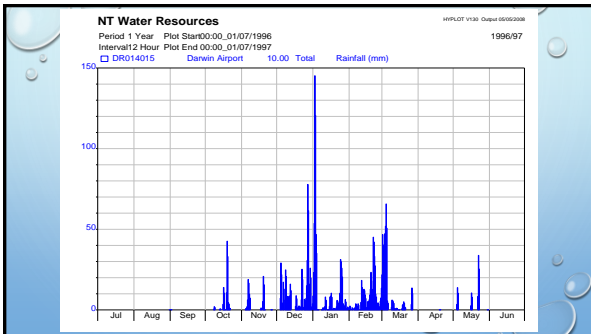
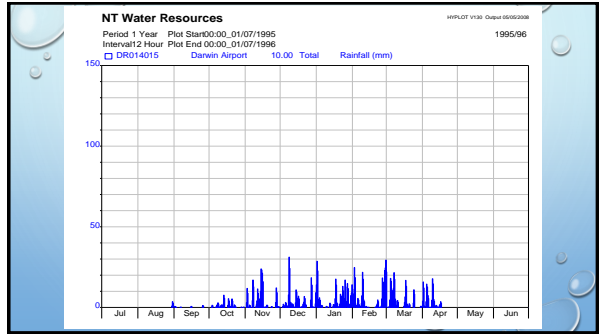
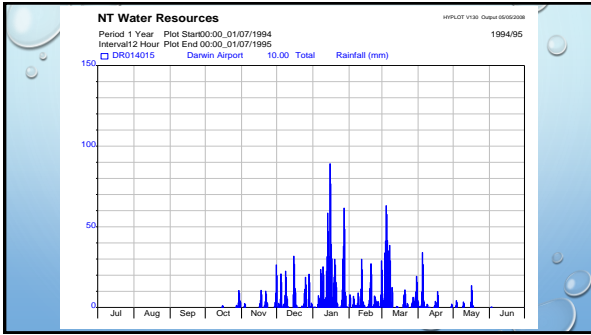


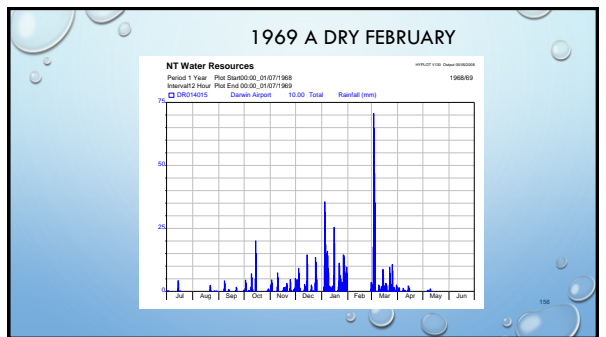
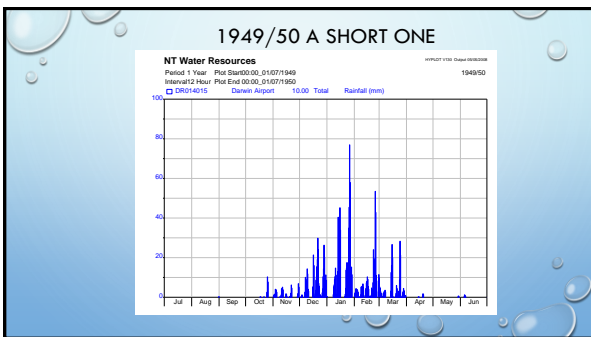
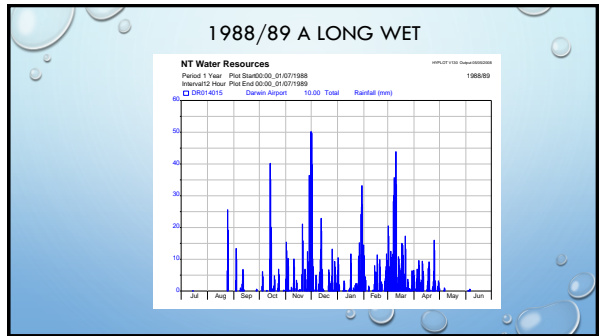
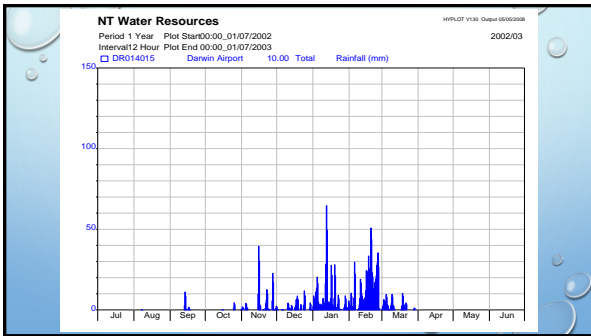
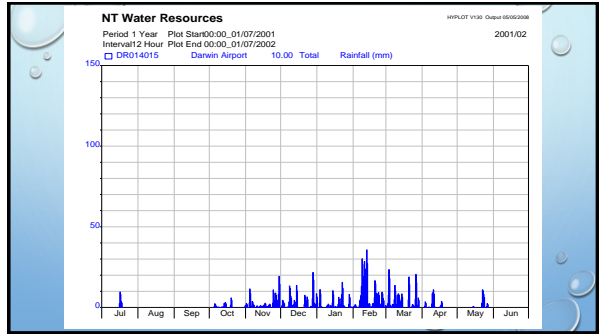
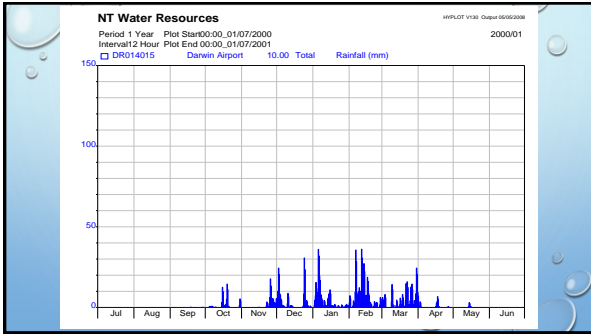


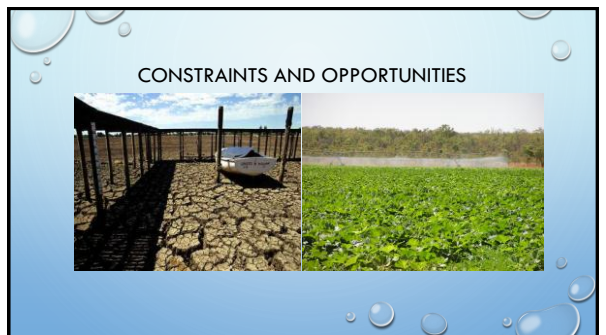
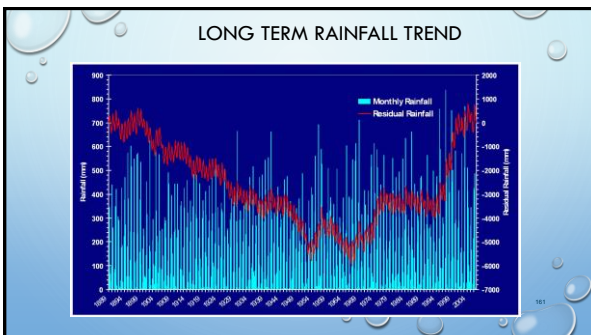
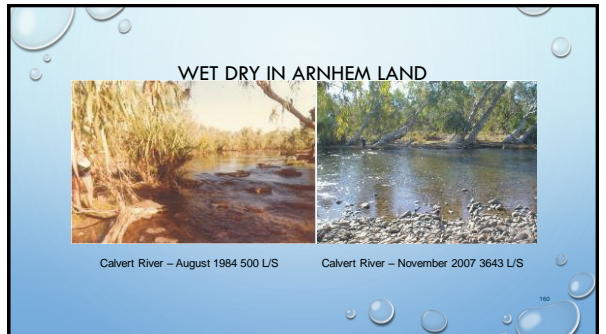
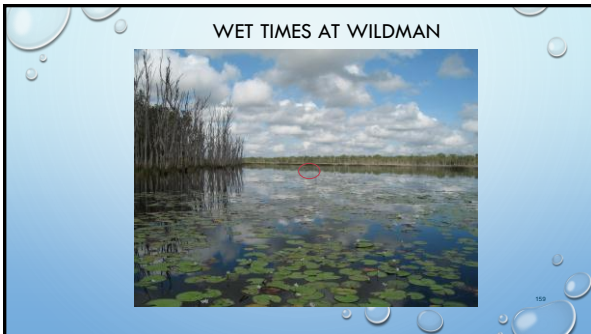
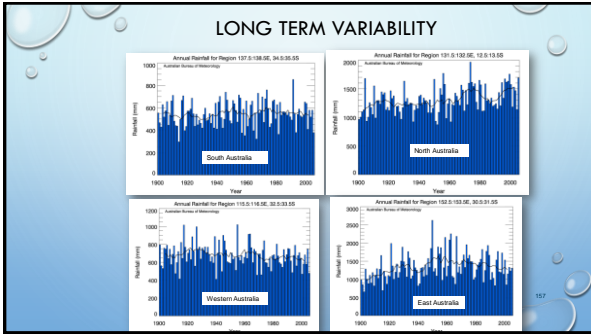


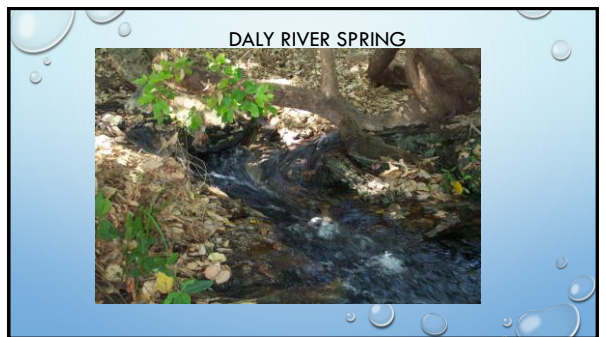
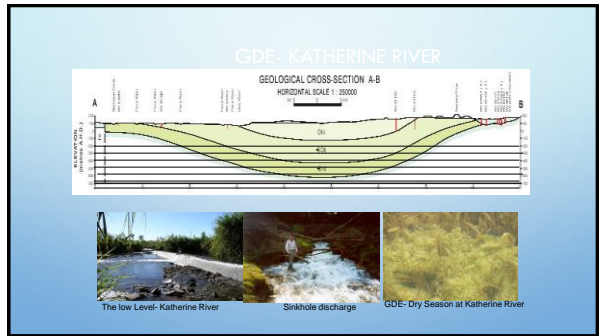
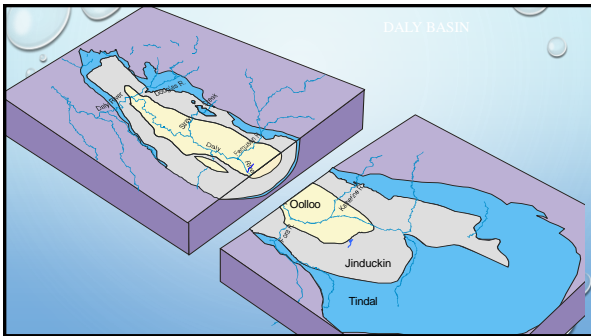
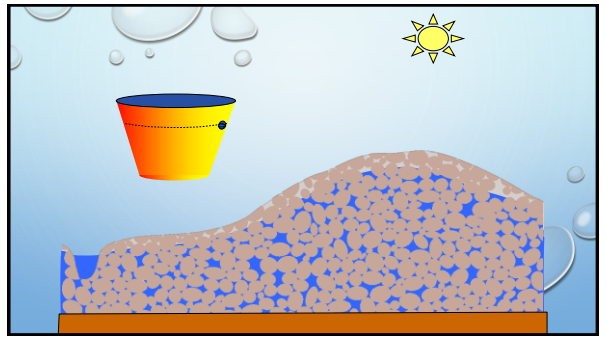
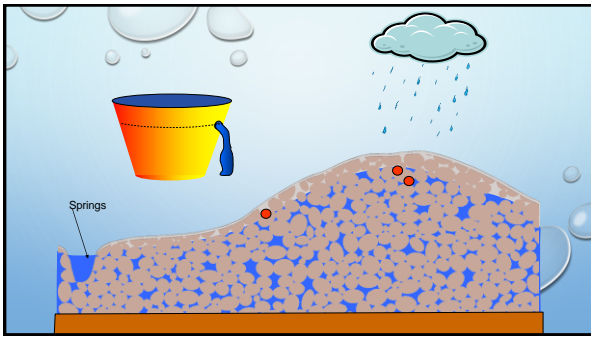


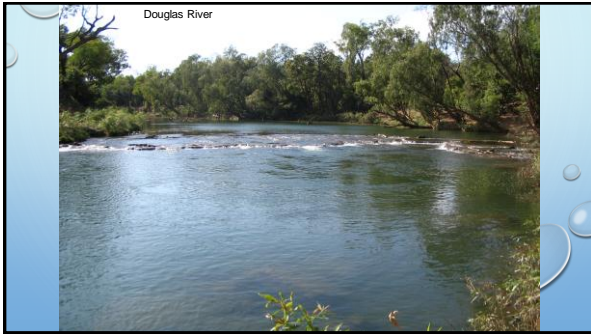












Douglas River



Dorrisvale Xing – Daly River



Daly River – Bank slumping

AGRICULTURAL TIMELINE IN THE NT

YEAR	MILESTONE	COMMENT
2008	MAJOR LAND USE CHANGE IN DALY	MS FORESTRY
2007	BANANA PRODUCTION STOPS	PRIMARILY DUE TO PANAMA DISEASE
2006	REVIEW SHOWS 1.56 CROPS TRIALED BY NT	
2002	TABLE GRAPES DECLINE	INMATEDOES
2001	MANGO SEA FREIGHT TRIALS	TO HONG KONG
1999	DOUBLING VALUE OF HORT EVERY 5 YEARS STOPS	INDUSTRY GROWTH PLATEAUS
1997	PANAMA DISEASE IN BANANAS	
	MAJOR SLUMP IN LIVE CATTLE	MAJOR GROWERS SPECIFIC
1996	CONSERVATION FARMING SYSTEM	NO TILL PLUS (SLOPE ROTATION)
1995	TIWI ISLAND FORESTRY PROJECT	ACACIA MANGUM FOR PULP IN PARTNERSHIP WITH TIC STARTS
1993	CITRUS CANKER OUTBREAK	
1992	LARGE SCALE BANANA PRODUCTION	
1991	LIVE CATTLE EXPORTS AFTER BVIC	RESURGENCE
1990	MELCHIE - THOMPSONS FARM	INDUSTRY COLLAPSES
	KENAF RESEARCH CEASES	
1989	TABLE GRAPES START AT TI TREE	

AG TIMELINE CONTINUED

YEAR	MILESTONE	COMMENT
1988	CUT FLOWHER INDUSTRY STARTS	
	NURSERY SECTOR EXPANDES	
	BRUCELOSS FREEDOM	
	LATE ROADWAY RESEARCH STARTS	
1984	KOENIGHE RESEARCHERS CLOSE	UNION DOPURE
1980	MAJOR CATTLE CULL FOR US HAMBURGER MARKET	
1980	MANABALOO MANGROVES START	SINGLE LARGE PLANTING
1975	BUFFALO EXPORTS RECOMMENCE	BAKING
AND 705	CATTLE PRICES FALL, LIVE CATTLE TRADE RESTRICTS	
1970	BVIC START	CALLING OF 78 INJECTED STOCK
1968	RICE OPERATIONS CEASE AT TORELLA	
1967	SPRINGBAY BOULDER BY REARMS	INDICATORS OF HA OF SOGINAMA
1960	COOL RIVER SCHEME DEVELOPED	
1964	LARGE SCALE SOWING OF IMPROVED PASTURES	
1955	TERRETIORY RICE LTD	LASTED 15 YEARS @ COASTAL PLAINS AND TORELLA
1940/50	LEGUME HAY FARMING DEVELOPED	

RICE FARMING AT HUMPTY DOO

HARVESTING AT HUMPTY DOO



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RICE CULTIVATION IN THE NORTH

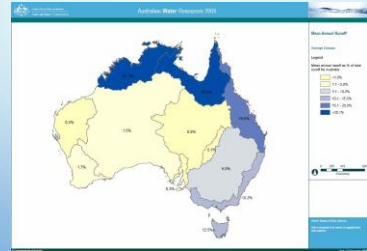


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OPPORTUNITIES – WET SEASON HARVESTING



SURFACE WATER DRAINAGE



OFF-STREAM STORAGE



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OPPORTUNITIES – WET SEASON CROPPING



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Opportunities – Forestry



OPPORTUNITIES - RESOURCE UTILISATION



STARK REALITIES OF A MODERN WORLD



A REMINDER

