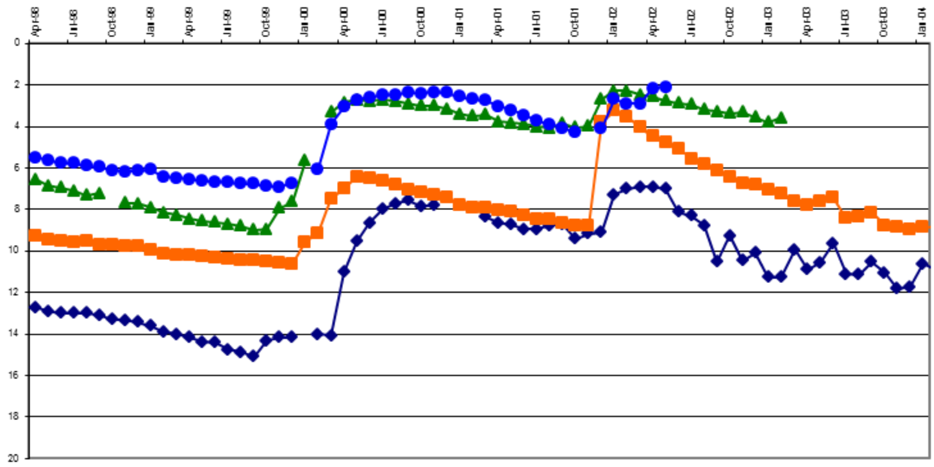
LIMPOPO REGION

QUARTERLY STATUS REPORT ON GROUNDWATER LEVEL TRENDS



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DIRECTORATE
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SUMMARY

The status as discussed in the report represents the situation at the end of the 1st quarter of the hydrological year, October to December, which is halfway through the wet season. Groundwater recharge thus far indicates no notable widespread occurrence but has been limited to a few local areas. The water level at 53.5% of stations monitored indicates a rise over the quarter with 64.7 % still being higher than the corresponding time last year. From trend analysis of the groundwater level time series it can be noted that some lower water levels do not indicate an unfavourable status of the resource if long-term trends are taken into consideration. Indication is that the water level status at up to 89% of the stations monitored is currently good. Two areas have been identified where the groundwater levels have been constantly declining for up to ten years. Areas such as these may be vulnerable to drought conditions if the trend persists. Over abstraction occurs at some localities which affect local groundwater levels negatively and lack of resource management is apparent. Sustainable use of a groundwater resource requires a professional approach to development and management.

1. BACKGROUND

Monitoring stations are equipped with electronic data loggers recording data at hourly intervals. Data is collected on a quarterly basis, processed and analysed to evaluate the status of groundwater in the Province. The period October to December 2014 is discussed and represents the first quarter of the hydrological year. Comparison is drawn between the situation at the start and end of the quarter; 1 October to 31 December 2014. Comparison is also made with the corresponding time the previous year as well as some long-term trends.

The distribution of the monitoring network is illustrated by MAP 1.

A number of specific monitoring stations on different projects are monitored and the results are reported at the conclusion of each project.

For various reasons all stations are not always accessible, which result in data not available. The main reason for current data gaps is however the lack of replacement instruments for old or defect instruments.

Electronic groundwater level data for this report was collected during January and February 2015.

2. GROUNDWATER LEVELS

2..1. DIFFERENCE IN GROUNDWATER LEVELS; OCTOBER TO DECEMBER 2014.

October - December 2014

Total	190	Stations

With data	155	Stations	81.6%

Water level			**Average(m)**	**%**
Down	72	Stations	-0.34	46.45%
Up	83	Stations	1.3	53.55%
Na change	0	Stations		0.00%
No Data	35	Stations		100.00%

The data represent the 1st quarter, start of the wet season, of the hydrological year. Only 81.6 % of the stations monitored has a data reading for both dates and this is mostly due to a lack of replacement instruments.

Despite it being the first half of the wet season 46.5% of stations where data was available still indicate lower water levels than at the start of the season. The average decline is only 0.34%. Indication is that widespread recharge did not occur this far but good recharge did however occur in some areas but mostly very localised. 83 Stations (53.5%) indicated higher groundwater levels with an average rise of 1.3m.

The distribution of stations with higher or lower groundwater levels from October to December is shown on MAP 2.

2..2. DIFFERENCE IN GROUNDWATER LEVELS; DECEMBER 2013 TO DECEMBER 2014

December 2013 -December 2014

Total	190	Stations

With data	136	Stations	71.6%

Water level			Average(m)	%
Down	46	Stations	0.95	33.82%
Up	88	Stations	1.34	64.71%
Na change	2	Stations		1.47%
No Data	54	Stations		100.00%

Data for both dates is only available for 71.6% of all stations. The levels at 64.7 % of these are currently higher than at the corresponding time last year. Lower groundwater levels are present at 33.8% of the stations.

Groundwater level trends are a response to many different factors and a declining trend in itself may not necessarily be an indication of an unfavourable situation.

The distribution of stations with higher or lower groundwater levels from December 2013 to December 2014 is shown on MAP 3.

3. DISCUSSION ON DIFFERENT TYPES OF GROUNDWATER LEVEL TRENDS IDENTIFIED FROM GRAPHS

To delineate areas characterized by similar groundwater behavior all trends were analyzed and grouped according to similarity. Groundwater levels affected by pumping were not considered. 175 trends were analyzed and 6 major types were identified. Long-term monitoring data for most of Limpopo is not available and the water level in relation to the depth of water strike in the boreholes, if available, is used as an indication of the status. This depth is considered the critical depth for a borehole below which the water level should not drop.

The distribution of different trend types is shown on **MAP 4**

<u>Notes:</u>

- *Water strike depth is the depth as which water was encountered during drilling, in else, the depth at which water flows into the hole. For this purpose the depth of the main strike was used.*
- *Piezometric level in a borehole represents the height above a datum plane at which the water level stands in boreholes penetrating a confined aquifer.*
- *Artesian borehole is a flowing borehole from which groundwater is discharged because the piezometric level is at an elevation higher than the borehole collar.*
- *Hydraulic head is the height to which water will rise in a borehole supported by the hydraulic pressure at a given point in a groundwater system*

*See **FIGURE 2** for further information*

3..1. TYPE 1: (GRAPH 1)

A continuous rising trend over a period of some years has been identified at only 4 stations and classified as type 1. The reason for this behavior is not clearly understood, 3 of these occur in Waterberg Sandstone aquifer. A large number of boreholes drilled in this formation are characterized by very deep water strikes, low yields and high piezometric head resulting in sub-artesian to artesian conditions. The constantly rising of the groundwater level in these boreholes since drilling may represent a very slow rise to the actual piezometric level but hampered by the low transmissivity.

The remaining borehole was drilled in granite with an exceptional deep water strike (184m) for the area and the reason may be the same as for the others.

3..2. TYPE 2 (GRAPH 2)

Groundwater level trends displaying clear seasonal fluctuations with a clear underlying rising trend were classified as type 2. This is the second largest group consisting of 36 (20.6%) of stations

3..3. TYPE 3 (GRAPH 3)

This type represents groundwater level trends displaying seasonal fluctuations around a mean with no clear underlying trend, rising or declining. This is the largest group with 49 (28%) of stations.

3..4. COMPARISON OF CURRENT, AVERAGE, LOWEST AND HIGHEST WATER LEVELS AND DEPTH TO WATER STRIKE FOR TREND TYPES 1, 2 & 3: (GRAPH 4)

Types 1 to 3 display stable to rising trends and together account for 50.9 % of the trends analyzed. Graph 4 serves as an example for discussion. For clarity sake the vertical axis was limited to 50m although 2 strikes exceeded that. The current water level varies around the average recorded over the past 6 to 10 years. The water level at B7 Wolkberg is the nearest to strike depth but still 5m above it. It is also above the lowest and the average level. The differences between the lowest and highest levels indicate no large fluctuations for some years.

3..5. TYPE 4 (GRAPH 5)

Type 4 trend display a decline in water level despite some seasonal recharge. The lack of long-term monitoring data is a restricting factor in evaluating the actual status in such areas by comparing to historical highs or lows. The trend displayed by this type clearly show that seasonal recharge do take place but not sufficient to reverse the declining trend. The decline may be a normal longer-term trend related to a “dry” period but could also be returning to normal head after abnormal high levels. There are 33 stations (18.9%) following this trend (**AREAS 2 to 5**; **Map 4**)

3..6. TYPE 5 (GRAPH 6)

19 Stations (10.9%) of the trends analyzed indicate a continuous decline with little or no seasonal fluctuations. The rate of decline is generally slow but steady and current water levels are the lowest

recorded since monitoring started here. Monitoring stations indicating a type 5 trend occur in the 2 areas marked (**AREA 6 to 7**; **MAP 4**)

3..7. AREA 6: COMPARISON OF CURRENT, AVERAGE, LOWEST AND HIGHEST WATER LEVELS AND DEPTH TO WATER STRIKE FOR TREND TYPE 5 (GRAPH 7)

Graph 7 indicates that the current water level is also the lowest recorded. As stated in 3.6, the rate of decline is very slow and there is very little difference between highest and lowest recorded water levels. Only one reasonable high rainfall event occurred in the past 5 years in this area and some recharge can be seen at A5 Tom Burke and A5 Setateng where after the decline continued as before. A major rainfall event is needed for levels to recover.

3..8. GROUNDWATER LEVEL TREND AT MONITORING STATION A5 TOM BURKE; (GRAPH 8)

On the previous graph, GRAPH 7, the current water level at station A5 Tom Burke is indicated as the one nearest to critical level (water strike depth) in area 6. The groundwater level trend for the past 7 years at this station is illustrated by GRAPH 8. The linear trend line indicate that if conditions as experienced during this time persist, it would still take years for the groundwater level to decline to the critical. One major recharge event can change the situation over a short time. If a prolonged drought condition develops the rate of decline may however increase shortening the available time to critical level.

3..9. AREA 7: COMPARISON OF CURRENT, AVERAGE, LOWEST AND HIGHEST WATER LEVELS AND DEPTH TO WATER STRIKE FOR TREND TYPE 5 (GRAPH 9)

In this area the current water levels are also the lowest recorded. Except for station B8 Sekgopo there is, as in area 6, not much difference between lowest and highest levels recorded. The current water level at B8Sekgopo is 2.4m above water strike and 7m for B8Nghalalume which is the next nearest to water strike depth.

3..10. GROUNDWATER LEVEL TREND AT MONITORING STATION B8 SEKGOPO (GRAPH 10)

In area 7 the water level at B8 Sekgopo is the most affected by the continuous decline and the trend is illustrated by GRAPH 10. The decline can be noted for the past 10 years since monitoring started. The linear trend line indicate that if conditions prevail without a major recharge event, the critical level may be reached in approximately 2 ½ years. At B8 Nghalalume 80 km downstream (graph not included) it will take more than 15 years

3..11. WATER LEVEL AND WATER STRIKE IN RELATION TO SURFACE ELEVATION (GRAPH 11 & MAP 6)

There is normally a close relation between groundwater levels and surface elevation with groundwater level representing a subdued version of the surface profile. Groundwater, as for surface water, flows from higher areas towards lower lying areas. Higher lying areas in a catchment, usually mountainous, would normally represent the recharge area with water draining downstream towards the middle, storage area, and the lower discharge area. Groundwater fluctuations tend to be larger in the recharge area because of this.

During times of limited recharge such as drought conditions the higher lying areas would then normally be more vulnerable because of the natural draining away of the groundwater. Over abstraction downstream can eventually have the same effect.

The profile presented by GRAPH 11 is that of the monitoring stations in area 7 discussed above. The effect of draining from the higher area of B8 Sekgopo where the water level is approaching strike depth is clear. It is vital that the distribution of monitoring points be such to cover aspects as this and should be considered in evaluation of the data.

3..12. TYPE 6 (GRAPHS 12 & 13)

The need for a major recharge event in some areas was mentioned above as well as the changing effect it can have in a short period of time. GRAPHS 12 & 13 illustrate the result of high intensity rainfall events recorded in some areas since 2013 **(AREAS 8 to 11; MAP 4)** Areas 10 and 11 represent areas of good recharge since 2013. Graph 12 gives an example of the trend in area 11 and graph 13 that of area 10. The status of groundwater levels in these areas is currently very good. Recharge in areas 8 and 9 are very local and restricted to 2 & 3 stations respectively.

4. SHORT AND LONG-TERM GROUNDWATER LEVEL TRENDS

Stations for which long-term data are available are limited both in number and spatially. There is however a good correlation with regard to the long-term trend displayed by most having such data. Trends for A6 Mokopane Dorp, A6 Mokopane Nyl and A6 Volspruit were selected as representing examples. The past 10 year trend is compared to the graph types identified above for stations with only short time data.

4..1. 10 YEAR GROUNDWATER LEVEL TRENDS AT MONITORING STATIONS A6 MOKOPANE DORP, A6 MOKOPANE NYL AND A6 VOLSPRUIT (GRAPH 14)

The 3 trends displayed fit with types 2, 3 & 4 graphs, seasonal fluctuating with underlying trend varying from rising to stable and declining. 64.5 % of short-term trends analyzed fall in this 3 types indicating a good correlation over this period between the majorities of trends.

4..2. LONG-TERM GROUNDWATER LEVEL TRENDS AT MONITORING STATIONS A6 MOKOPANE DORP, A6 MOKOPANE NYL AND A6 VOLSPRUIT (GRAPH 15)

The long-term trends displayed by this graph indicate that the current situation compared to that during the drought period experienced in the eighties to mid-nineties is good. Given the good correlation over the shorter term as shown above the same may be true historically. This would lend to the assumption that the current situation at other monitoring stations with only shorter term data with good correlation over the short-term may also be good.

5. LOCAL EFFECT OF OVER ABSTRACTION (GRAPH 16)

The graph gives a clear indication of the effect of uncontrolled abstraction has on groundwater levels at local level. The sharp decline displayed is the result of abstraction from a single borehole approximately 200m away from the monitoring station. This use is clearly not sustainable.

6. OVERVIEW OF THE OVERALL SITUATION

It was shown above that trend types 1 to 3 (stable to rising) represent a healthy status which comprise 50.9% of trends analyzed. Type 6 represents stations with recent good recharge and also a healthy status which added brings the total to 70.3% of stations raising no concern. If the deduction made in section 4.2 by comparing the correlation to stations with long-term data is true, the total stations currently in a good situation comes to 89.1 %

Type 1	Continuous rising trend with little or no seasonal fluctuation	2.3%
Type 2	Seasonal fluctuation with an underlying rising trend	20.6%
Type 3	Seasonal fluctuation with stable water levels around a mean	28.0%
	Sub total	**50.9%**
Type 6	Long period of decline with good recharge since 2013	19.4%
	Sub total	**70.3%**
Type 4	Seasonal fluctuation with an underlying declining trend	18.9%
	Total	**89.1%**

There is good indication that the groundwater status with regard to quantity is good in most areas.

7. AREAS POTENTIALLY VULNERABLE TO DROUGHT CONDITIONS

Although some local conditions raising concern due to single point over abstraction exist, it is limited to the immediate area as indicated in section 5. At this stage there is no cause for immediate concern in any area but 2 potentially vulnerable areas have been identified characterized by type 5 trends **(MAP 5)**

7.1. AREA 6

There is no reason for concern at this stage about area 6 in the Tom Burke area but the situation will be monitored. Because of the already steady decline in water levels and an apparent lack of sufficient recharge the area can become vulnerable to drought. The area can possibly still cope with a 3 to 4 year dry spell but hopefully a good recharge period may occur before the situation becomes a reason for serious concern.

7.2. AREA 7

The area stretches from Sekgopo area northeast past Giyani towards the Kruger National Park and northwards to Malumulele area. The same is valid as for area 6 above but this area is somewhat more vulnerable especially in Sekgopo area. The situation will also be monitored.

8. RAINFALL (FIGURE 1)

FIGURE 1 was compiled by the South African Weather Services and obtained from:

http://www.weathersa.co.za/climate

From the figure it can be noted that the Limpopo Province did not experience above normal rainfall up to December 2014. In the more arid areas which receive lower annual rainfall good recharge normally depend on above average high intensity rainfall incidents. Both potentially vulnerable areas identified received normal to below normal rainfall up the December.

9. IMPORTANCE OF GROUNDWATER MANAGEMENT

Utilization of any resource has to be well managed to ensure sustainability. Unfortunately groundwater management is mostly ignored. Monitoring of groundwater levels is one of the most important tools in groundwater management with regard to quantity. It is easy to implement and costs involved is relatively low but the information gathered is of great importance. The situation as illustrated by **GRAPH 16** leaves no doubt that the abstractor is not monitoring or managing the resource.

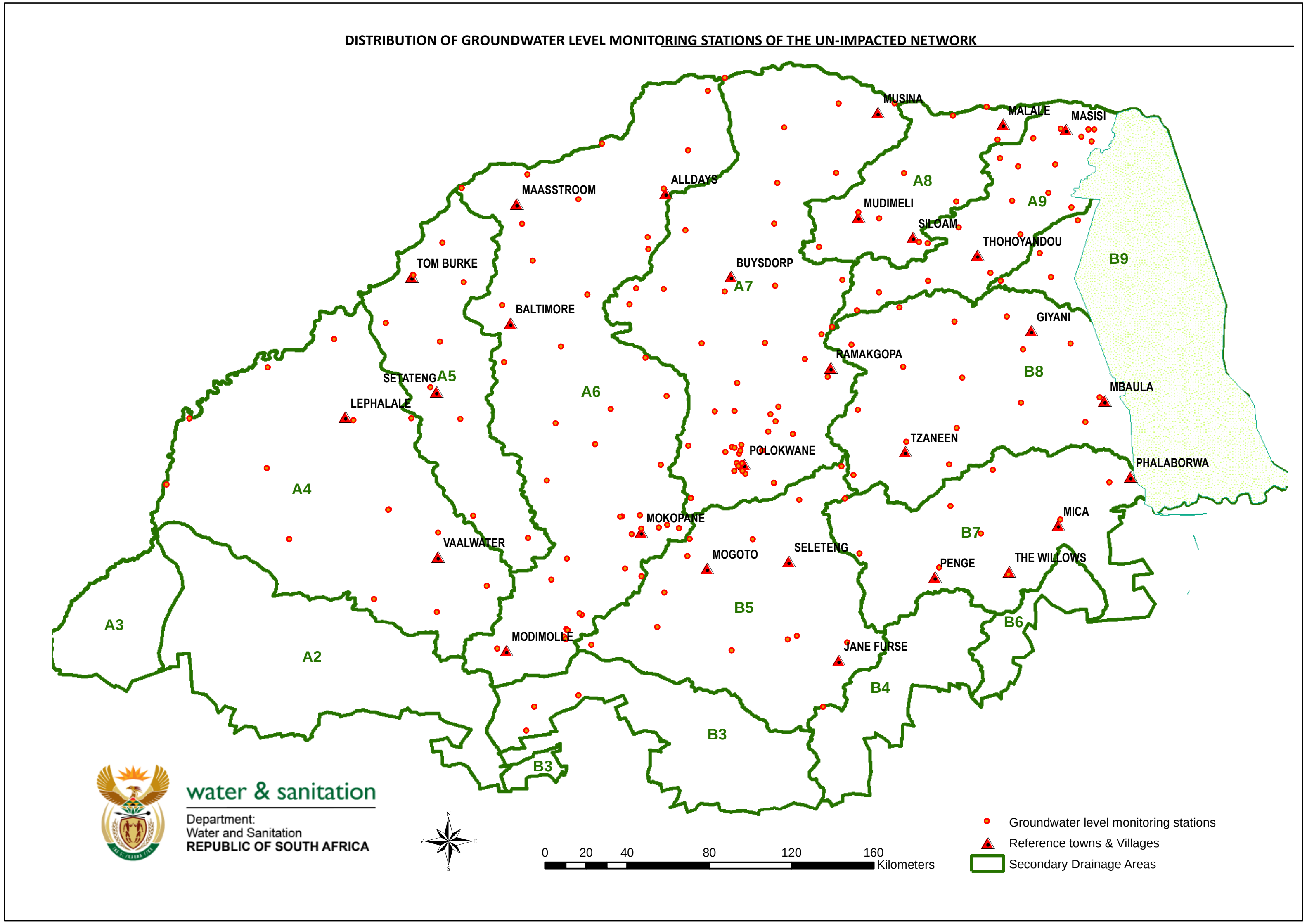
Groundwater is one of our most valuable resources providing in the daily water needs of a vast number of people with the potential of improving the living conditions of many more.

10. ACKNOWLEDGEMENT

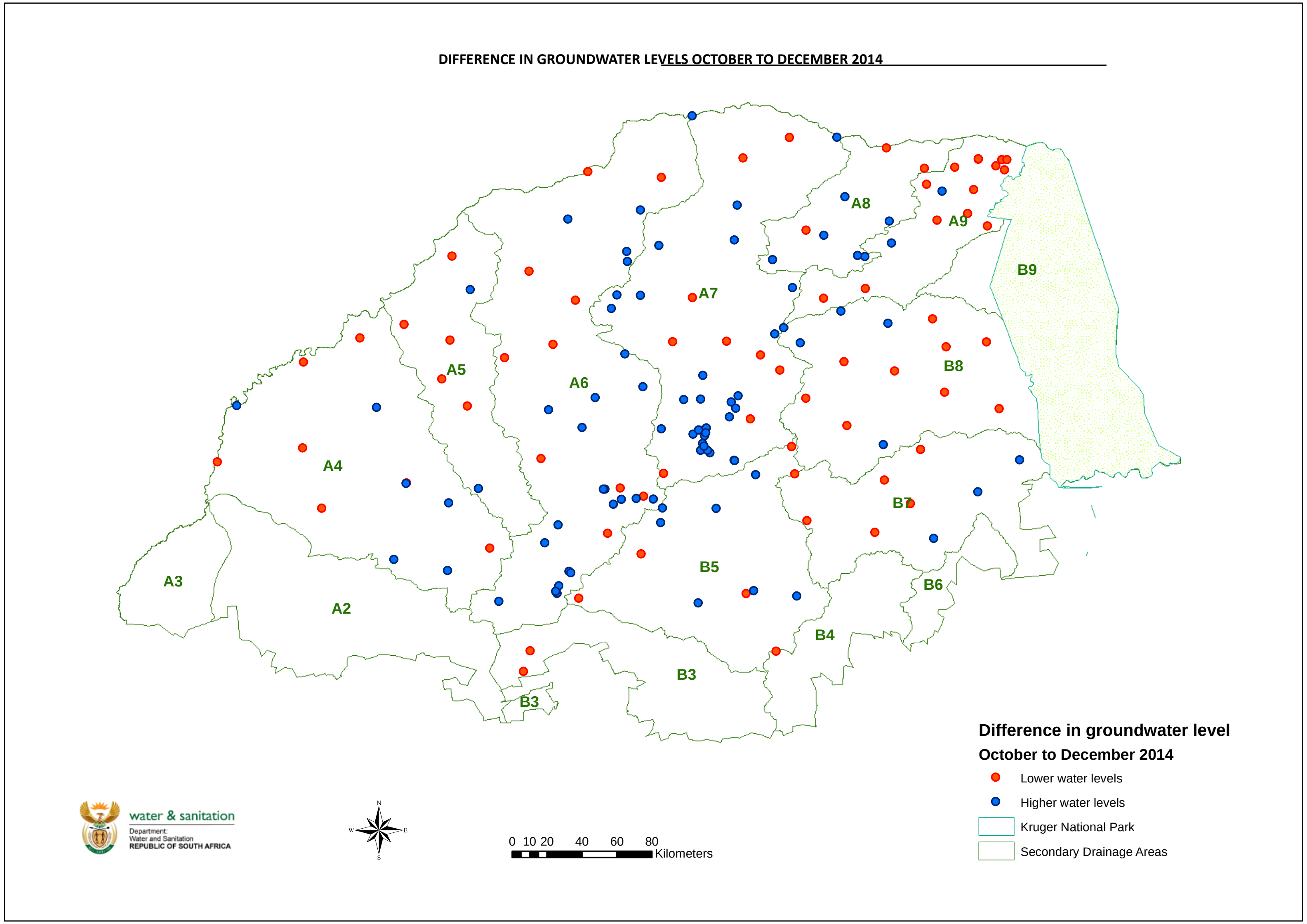
http://www.weathersa.co.za/climate RAINFALL AND FORECAST MAPS; FIGURES 1-4

Info@saweather.co.za LIMPOPO RAINFALL DATA

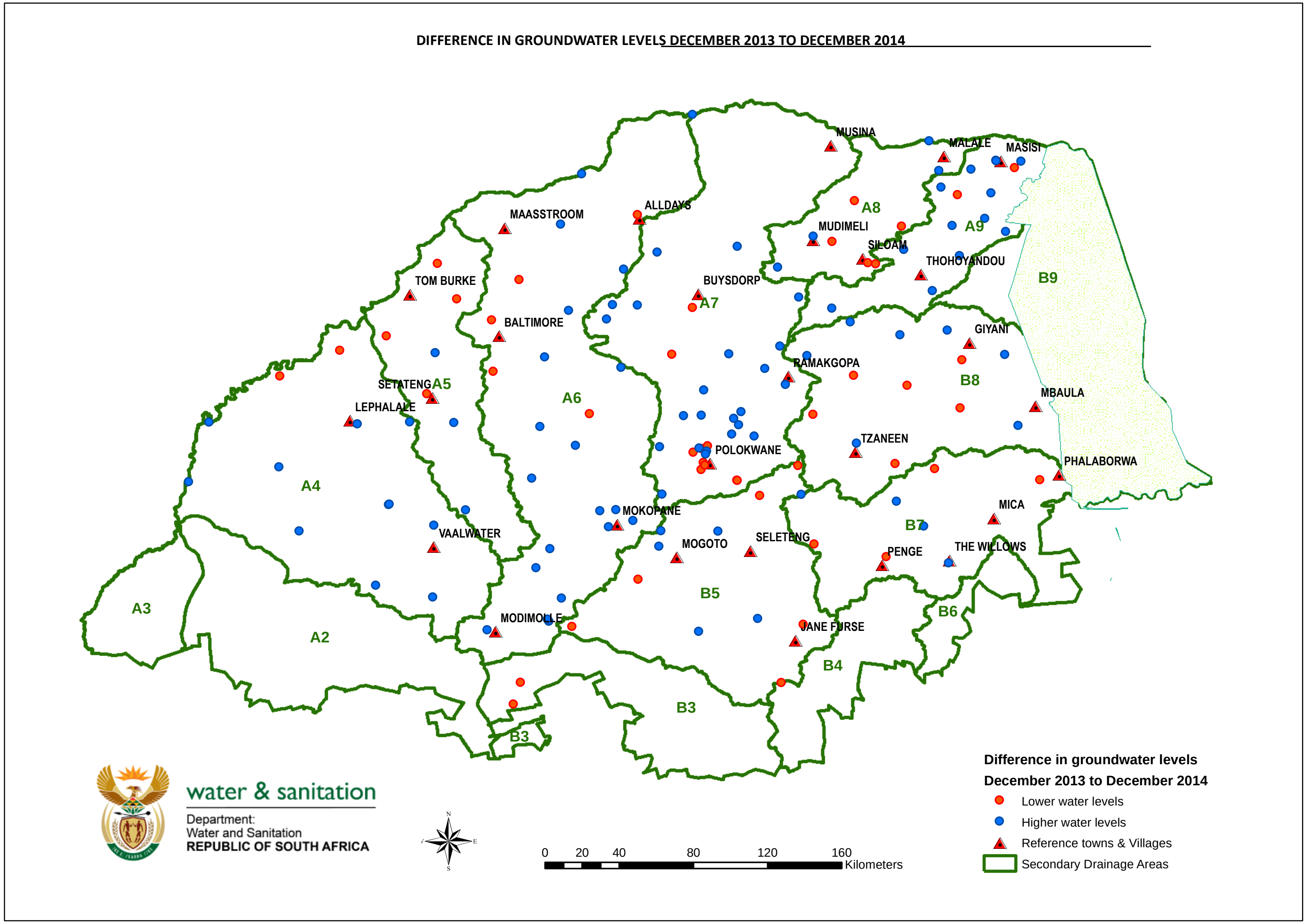
http://oceanworld.tamu.edu/resources/environment-book/groundwater.html FIGURE 2


DISTRIBUTION OF GROUNDWATER LEVEL MONITORING STATIONS OF THE UN-IMPACTED NETWORK
MUSINA
MALALE
MASISI
ALLDAYS
MAASSTROOM
A8
MUDIMELI
A9
SILOAM
THOHOYANDOU
B9
BUYSDORP
TOM BURKE
A7
BALTIMORE
GIYANI
RAMAKGOPA
B8
SETATENG
A5
A6
MBAULA
LEPHALALE
TZANEEN
POLOKWANE
PHALABORWA
A4
MICA
MOKOPANE
B7
VAALWATER
MOGOTO
SELETENG
PENGE
THE WILLOWS
B5
B6
A3
A2
MODIMOLLE
JANE FURSE
B4
B3
B3
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA
0
20
40
80
120
160
Kilometers
Groundwater level monitoring stations
Reference towns & Villages
Secondary Drainage Areas

MAP 1

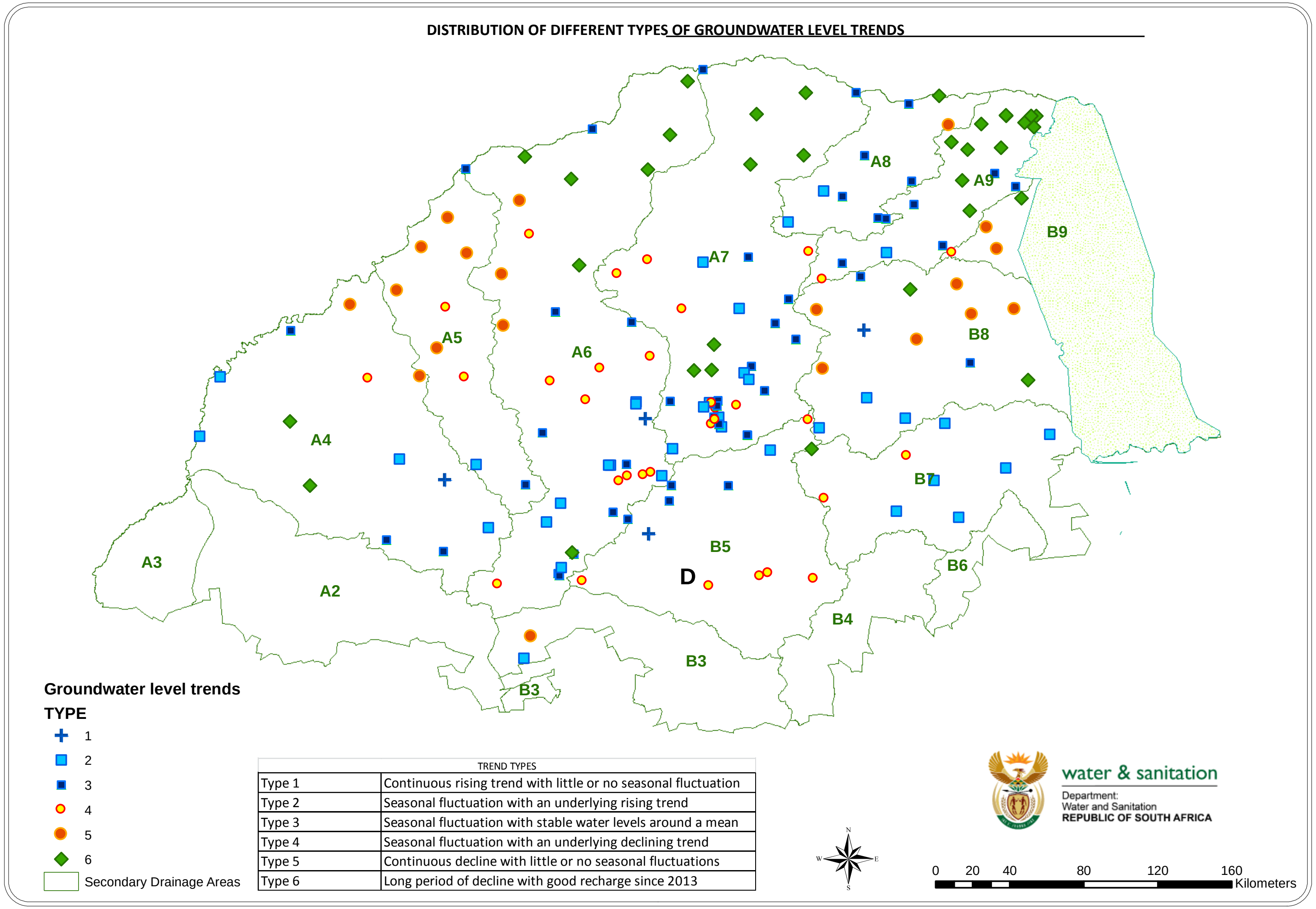

DIFFERENCE IN GROUNDWATER LEVELS OCTOBER TO DECEMBER 2014
A2
A3
A4
A5
A6
A7
A8
A9
B3
B3
B4
B5
B6
B7
B8
B9
Difference in groundwater level
October to December 2014
Lower water levels
Higher water levels
Kruger National Park
Secondary Drainage Areas
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA
0 10 20 40 60 80
Kilometers

MAP 2



DIFFERENCE IN GROUNDWATER LEVELS DECEMBER 2013 TO DECEMBER 2014
MUSINA
MALALE
MASISI
ALLDAYS
MAASSTROOM
A8
MUDIMELI
A9
SILOAM
THOHOYANDOU
TOM BURKE
BUYSDORP
B9
A7
BALTIMORE
GIYANI
RAMAKGOPA
SETATENG
A5
A6
B8
LEPHALALE
MBAULA
TZANEEN
POLOKWANE
PHALABORWA
A4
MICA
MOKOPANE
B7
VAALWATER
SELETENG
MOGOTO
PENGE
THE WILLOWS
B5
A3
B6
MODIMOLLE
A2
JANE FURSE
B4
B3
B3
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA
0
20
40
80
120
160
Kilometers
Difference in groundwater levels
December 2013 to December 2014
Lower water levels
Higher water levels
Reference towns & Villages
Secondary Drainage Areas

MAP 3

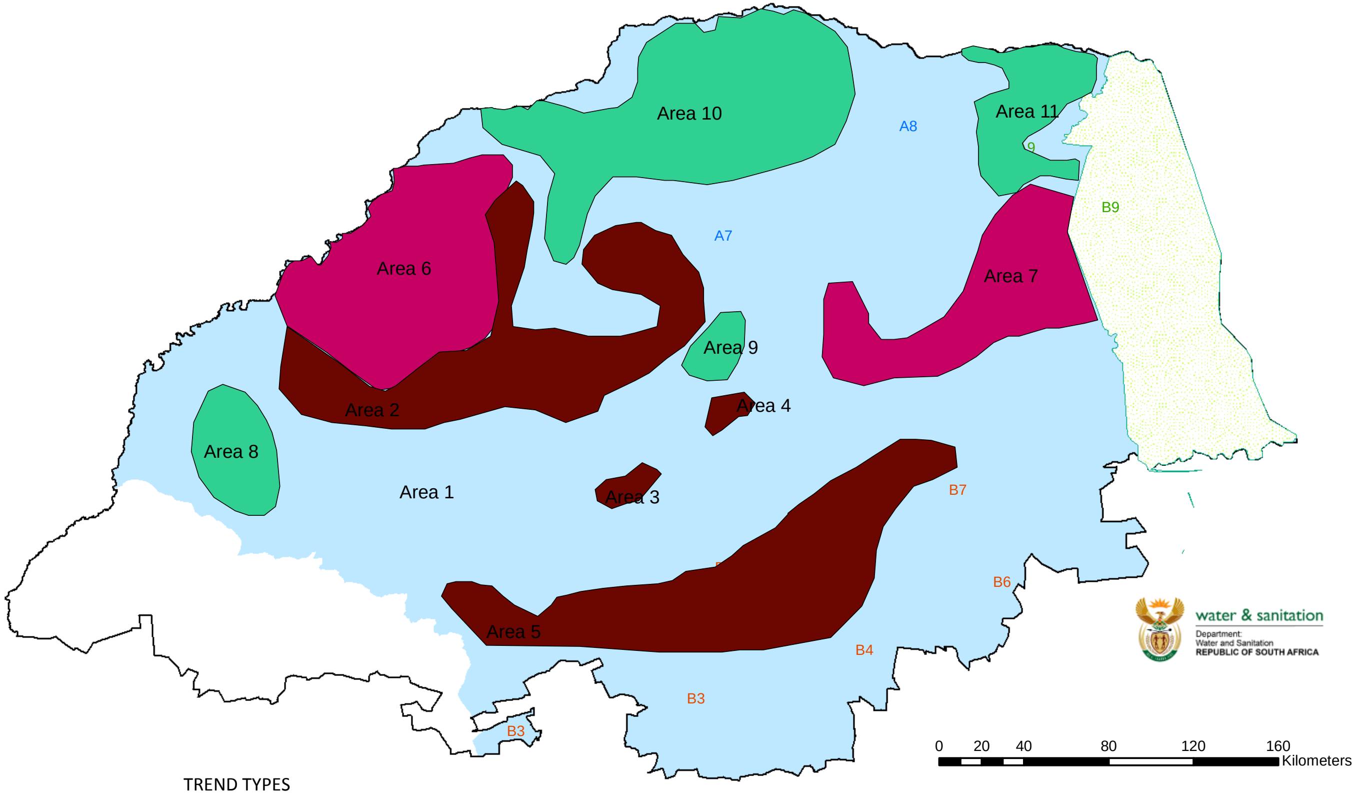


TREND TYPES

Type 1	Continuous rising trend with little or no seasonal fluctuation
Type 2	Seasonal fluctuation with an underlying rising trend
Type 3	Seasonal fluctuation with stable water levels around a mean
Type 4	Seasonal fluctuation with an underlying declining trend
Type 5	Continuous decline with little or no seasonal fluctuations
Type 6	Long period of decline with good recharge since 2013

MAP 4

DISTRIBUTION OF DIFFERENT TYPES OF GROUNDWATER LEVEL TRENDS



TREND TYPES

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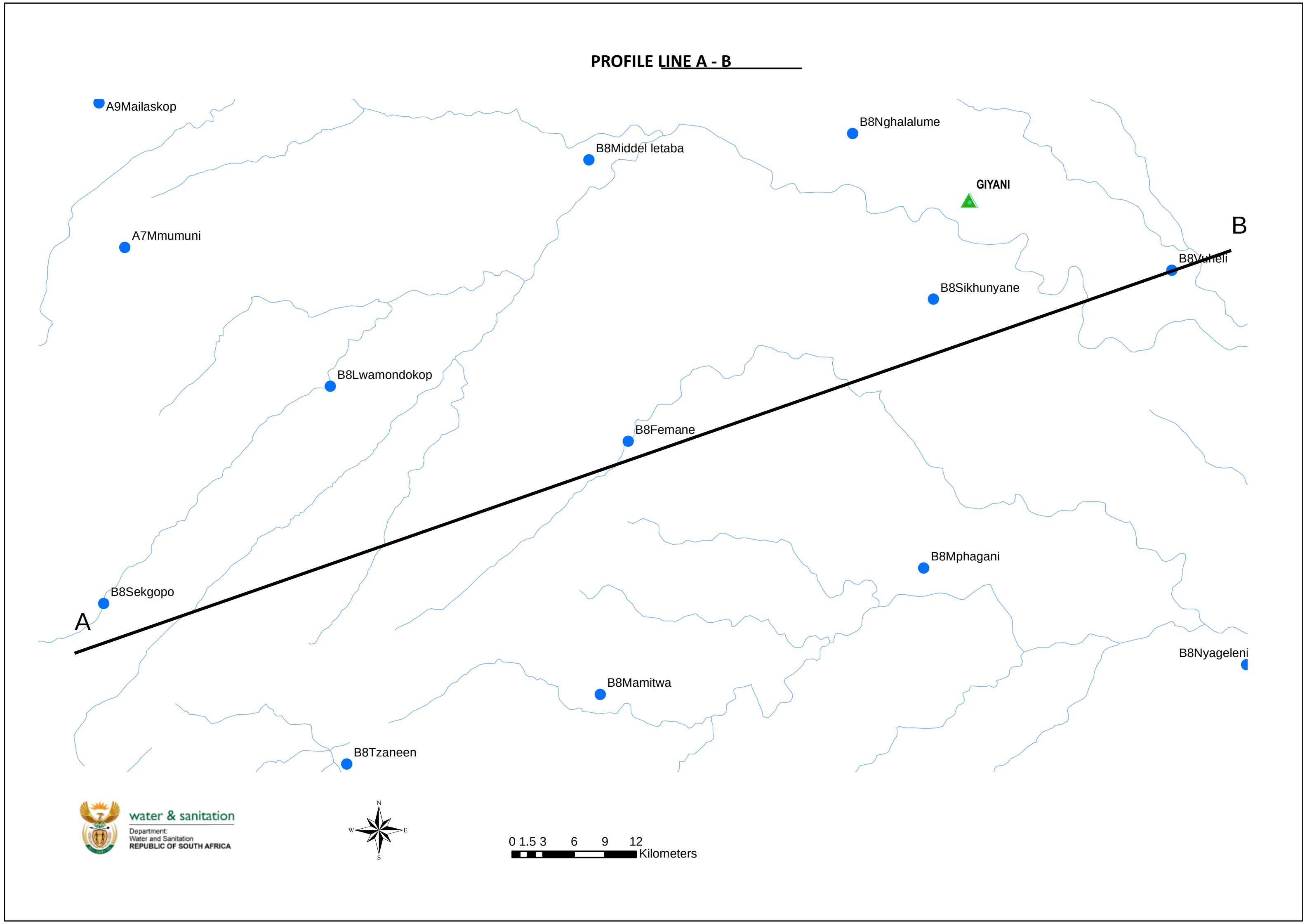
Type 6	Long period of decline with good recharge since 2013

AREAS WITH SIMILAR TREND TYPES

Type 1, 2 & 3	Area 1	
Type 4	Areas 2 to 5	
Type 5	Areas 6 to 7	
Type 6	Areas 8 to 11	

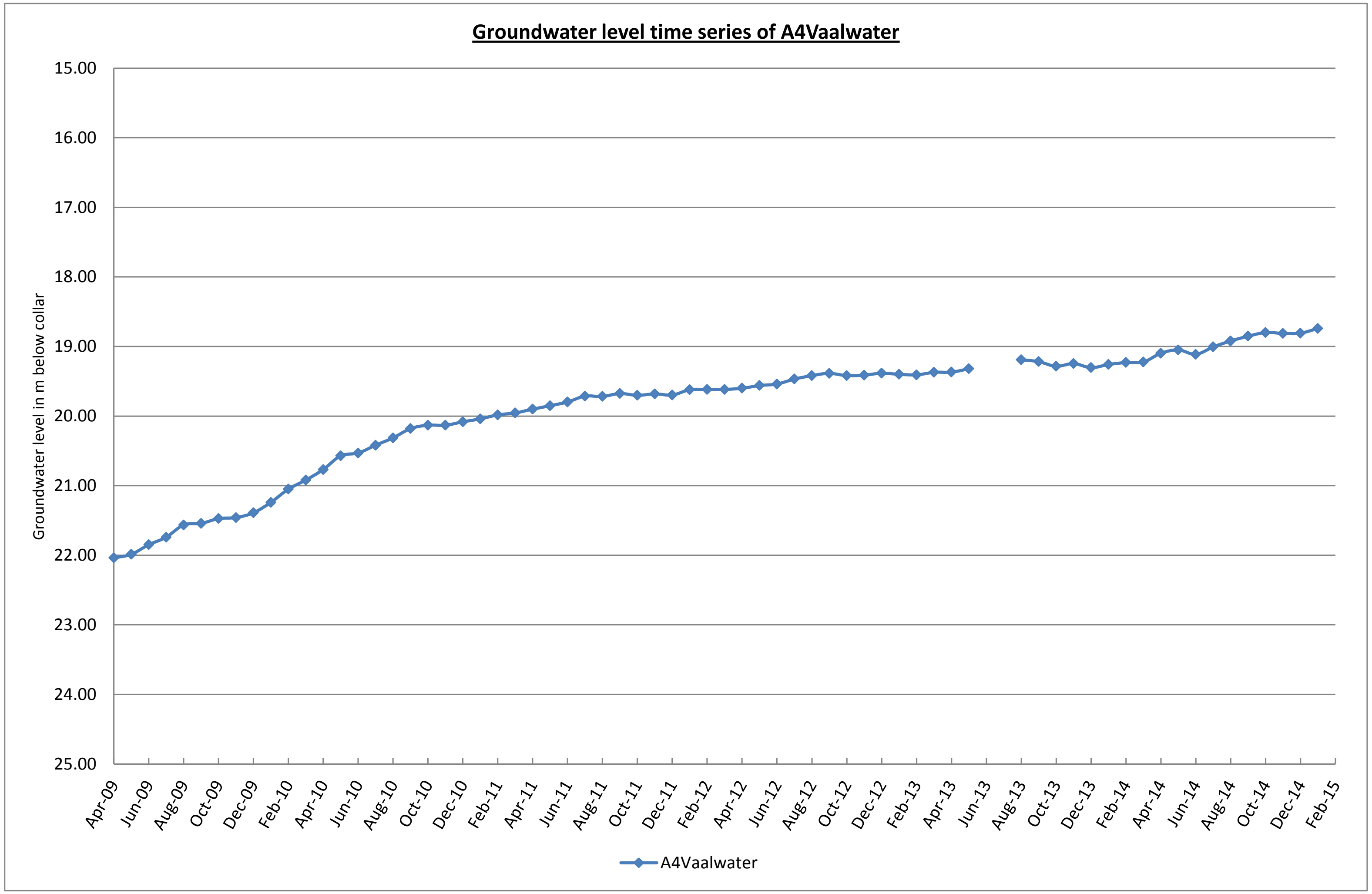
MAP 5



PROFILE LINE A - B
A9Mailaskop
B8Middel letaba
B8Nghalalume
GIYANI
A7Mmumuni
B
B8Vuheli
B8Sikhunyane
B8Lwamondokop
B8Femane
B8Mphagani
B8Sekgopo
A
B8Nyageleni
B8Mamitwa
B8Tzaneen
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA
N
W
E
S
0 1.5 3 6 9 12
Kilometers

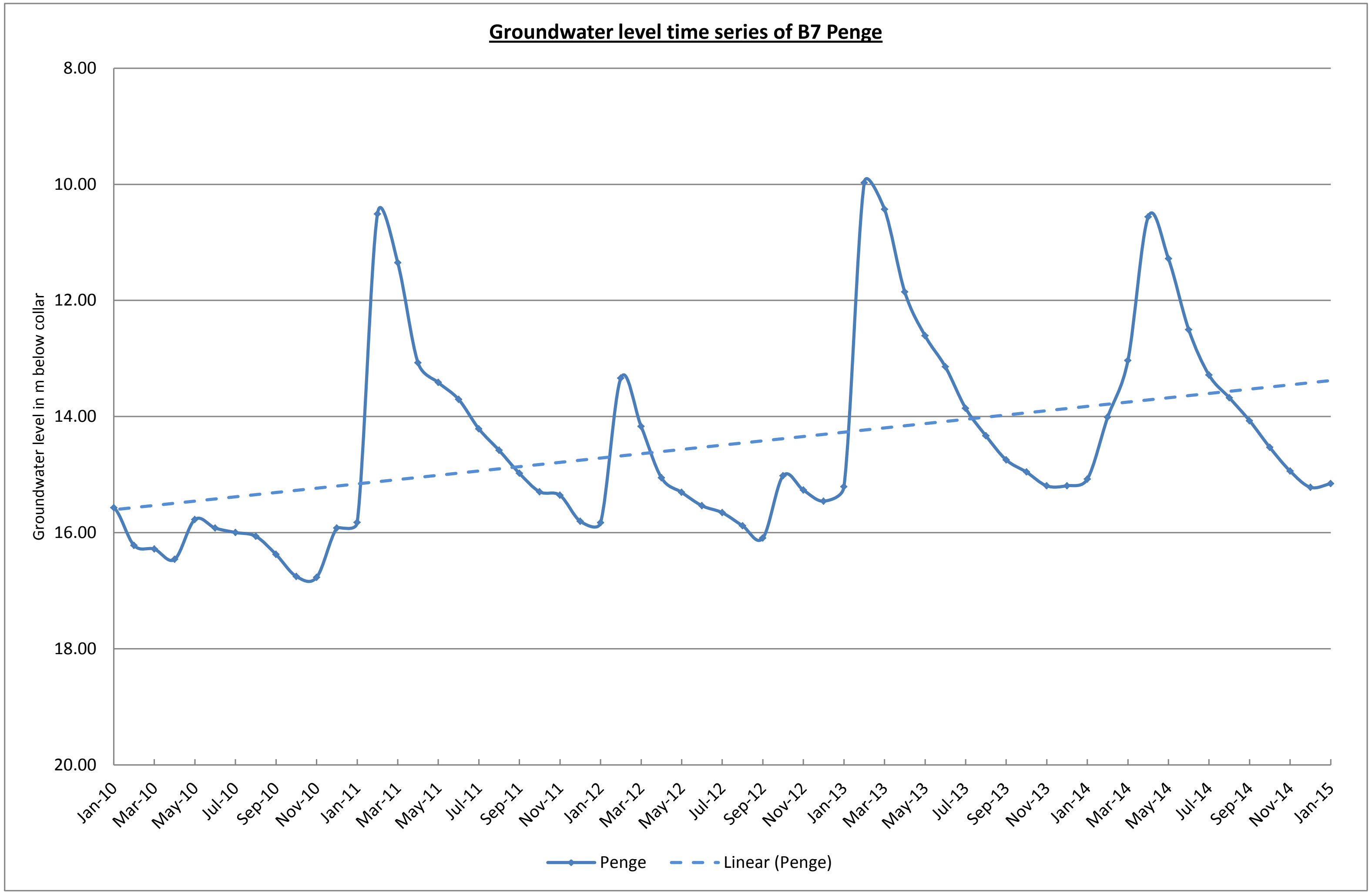
MAP 6

EXAMPLE OF TYPE 1 TREND (Continuous rising trend)



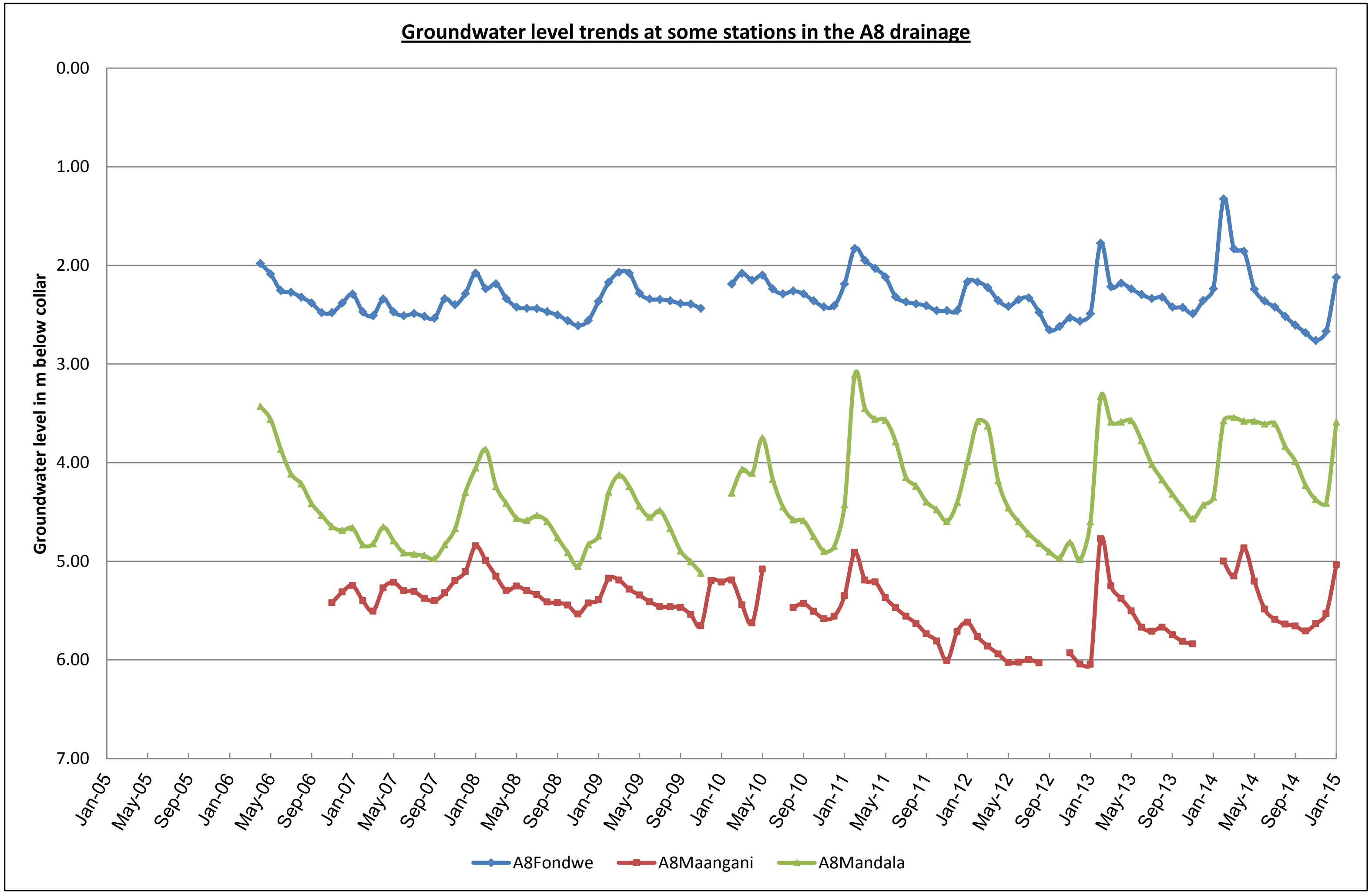
GRAPH 1

EXAMPLE OF TYPE 2 TREND (Seasonal fluctuations with underlying rising trend)

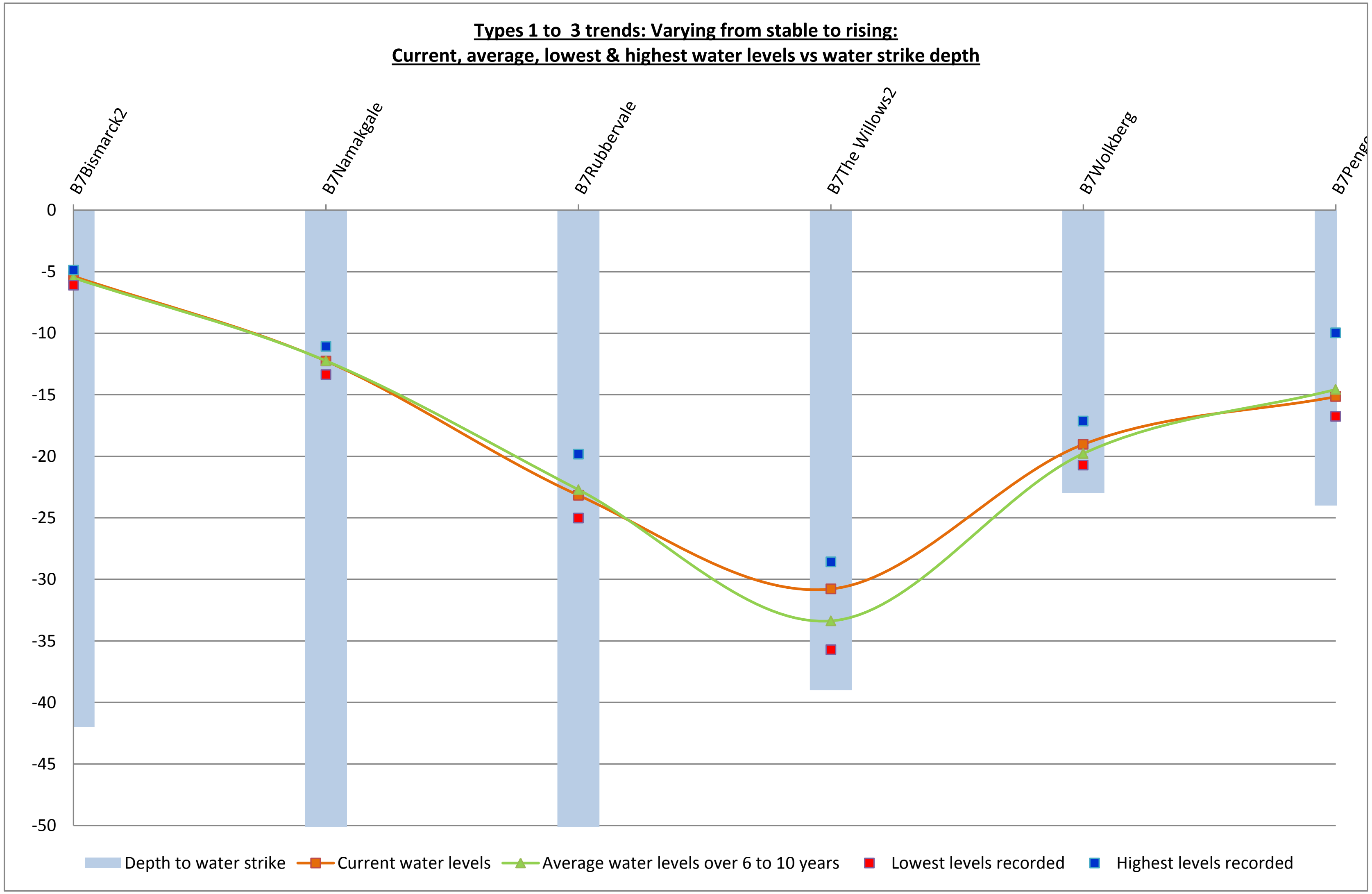


GRAPH 2

EXAMPLE OF TYPE 3 TREND (Seasonal fluctuation with stable water levels around a mean)



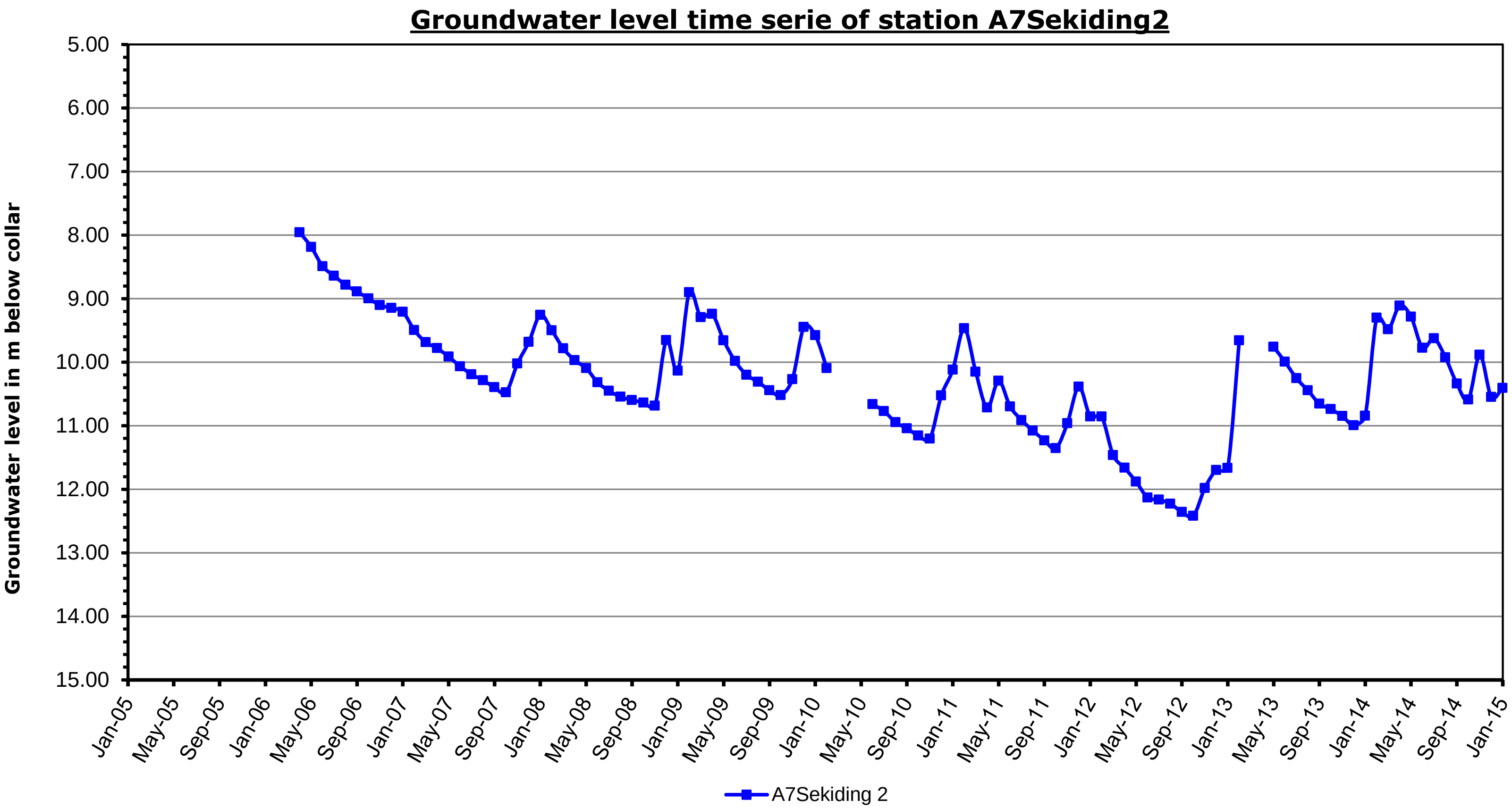
GRAPH 3



Types 1 to 3 trends: Varying from stable to rising:
Current, average, lowest & highest water levels vs water strike depth
B7Bismarck2
B7Namakgale
B7Rubbervale
B7The Willows2
B7Wolkberg
B7Penge
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Depth to water strike
Current water levels
Average water levels over 6 to 10 years
Lowest levels recorded
Highest levels recorded

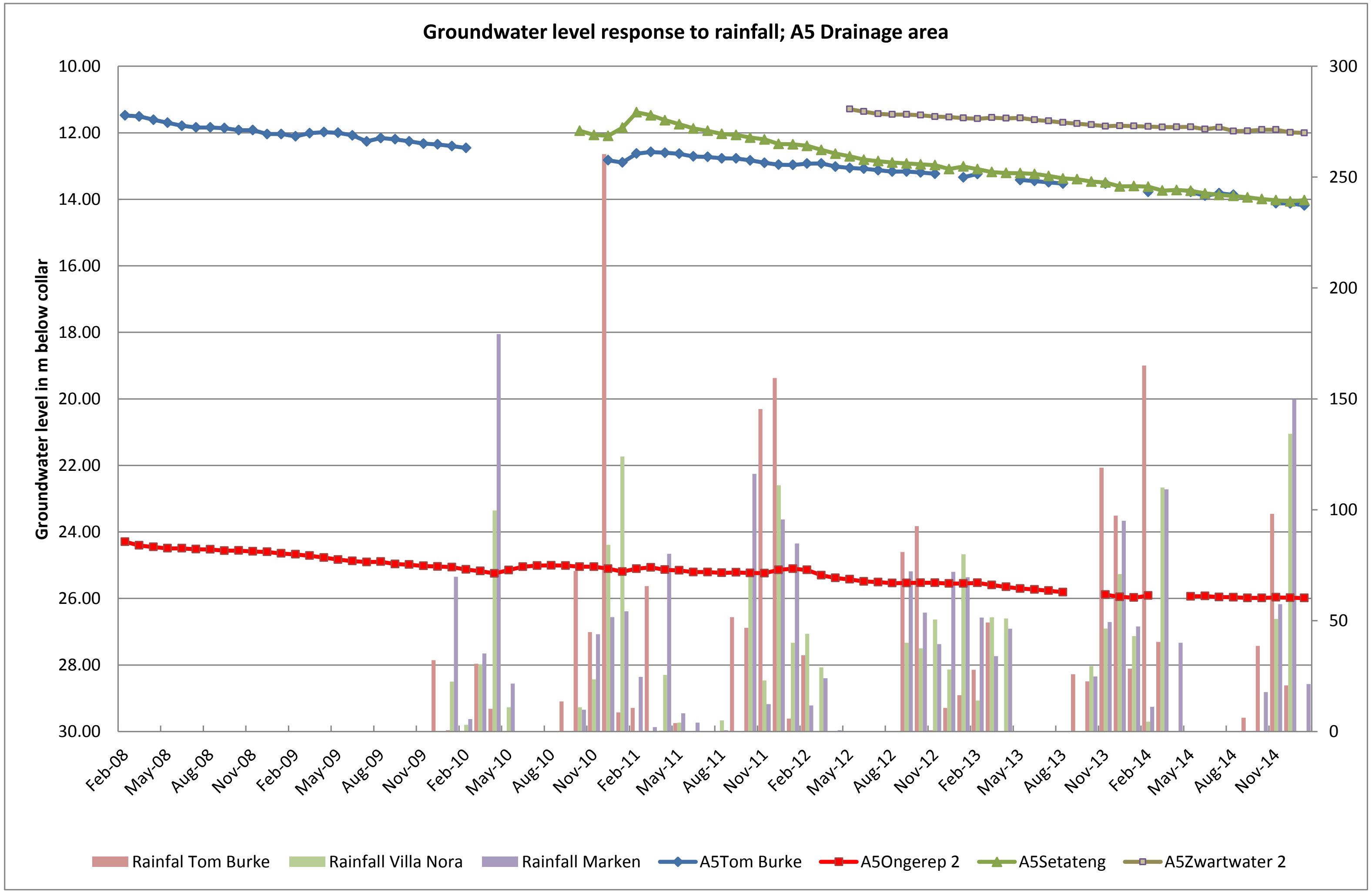
GRAPH 4

EXAMPLE OF TYPE 4 TREND (Seasonal fluctuation with an underlying declining trend)

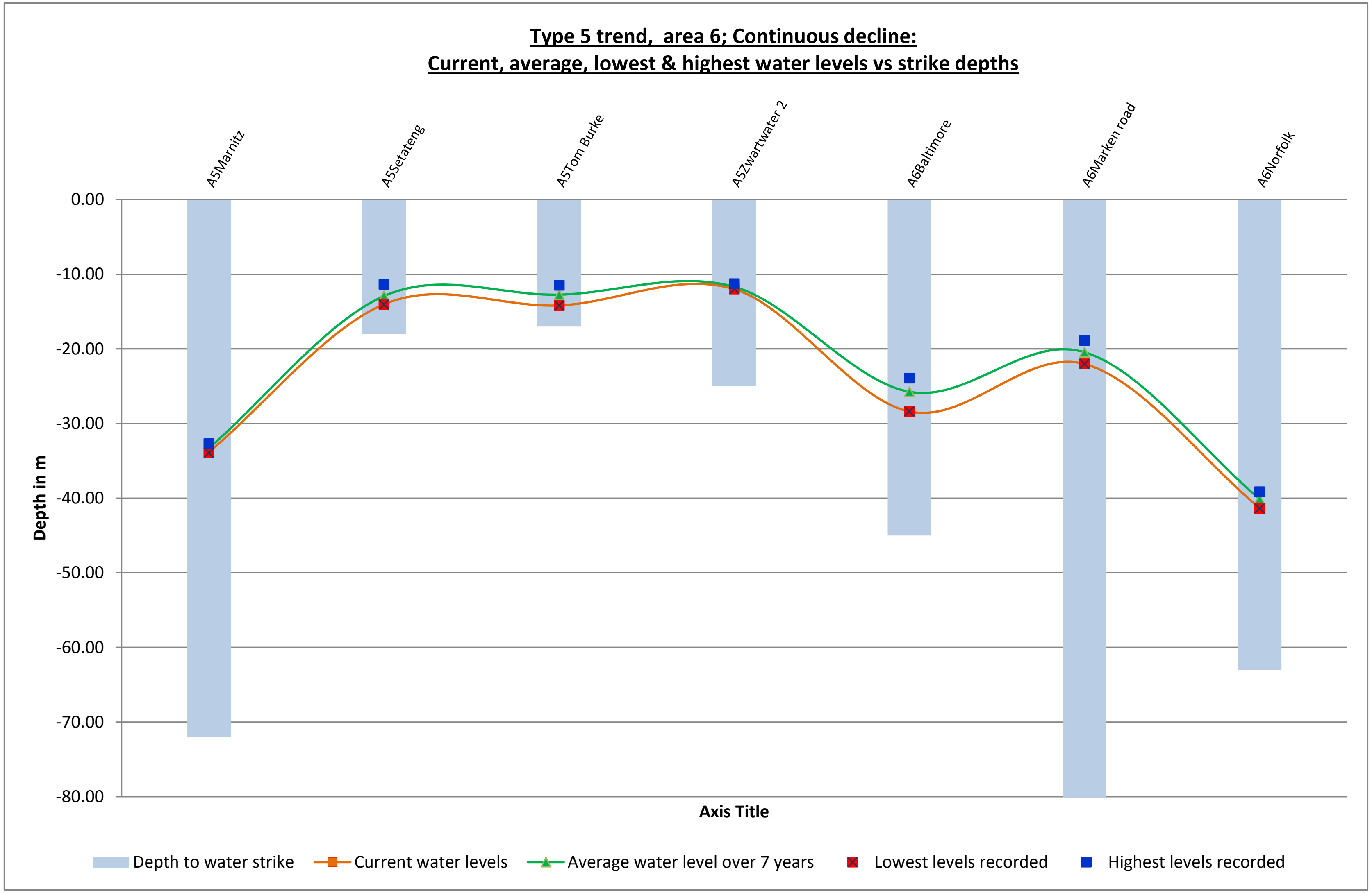


GRAPH 5

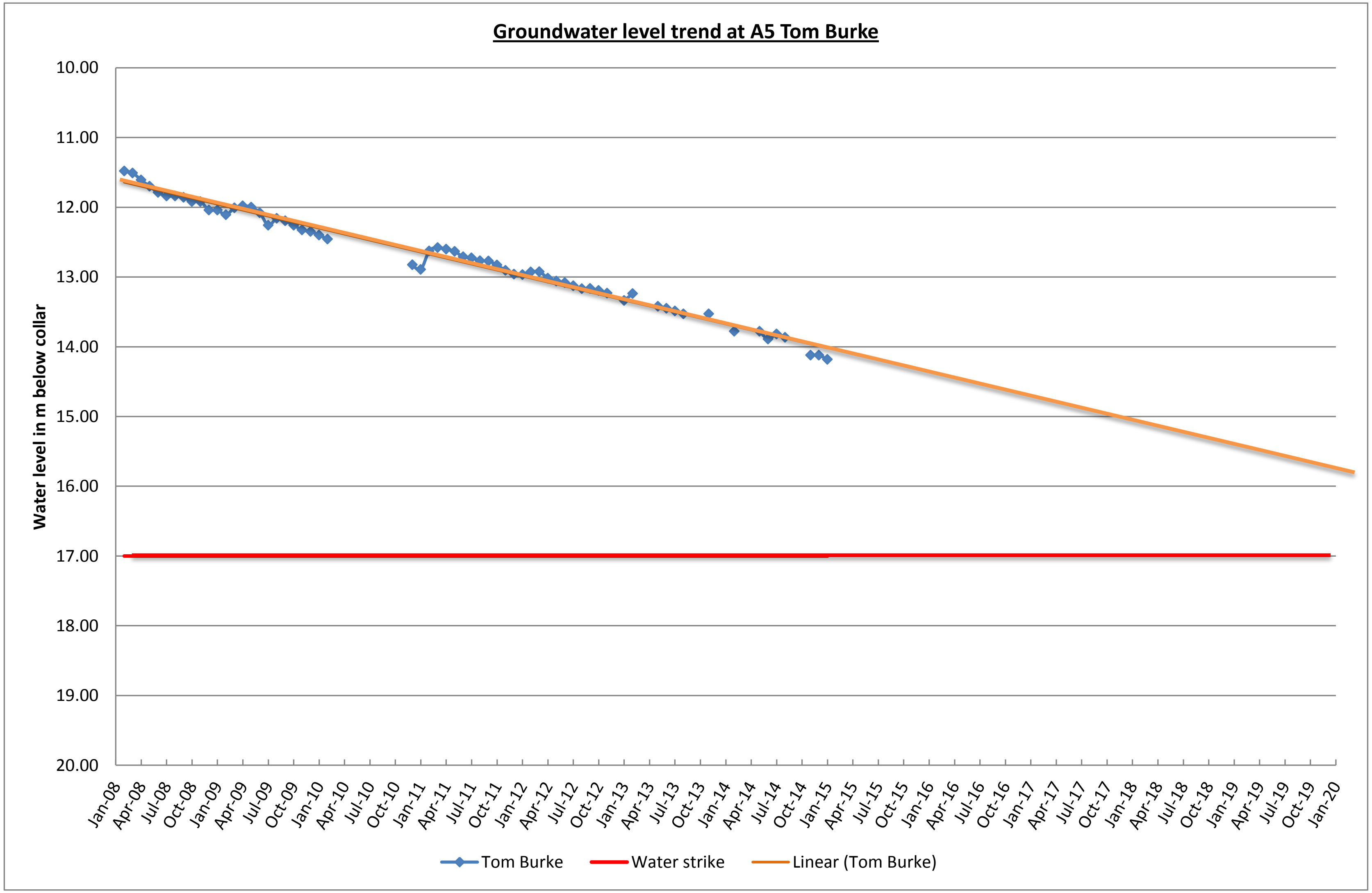
EXAMPLE OF TYPE 5 TREND (Continuous decline with little or no seasonal fluctuations)



GRAPH 6


Type 5 trend, area 6; Continuous decline:
Current, average, lowest & highest water levels vs strike depths
A5Marnitz
A5Setateng
A5Tom Burke
A5Zwartwater 2
A6Baltimore
A6Marken road
A6Norfolk
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Depth in m
Axis Title
Depth to water strike
Current water levels
Average water level over 7 years
Lowest levels recorded
Highest levels recorded

GRAPH 7



Groundwater level trend at A5 Tom Burke
Water level in m below collar
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
Jan-08
Apr-08
Jul-08
Oct-08
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
Oct-12
Jan-13
Apr-13
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Jan-14
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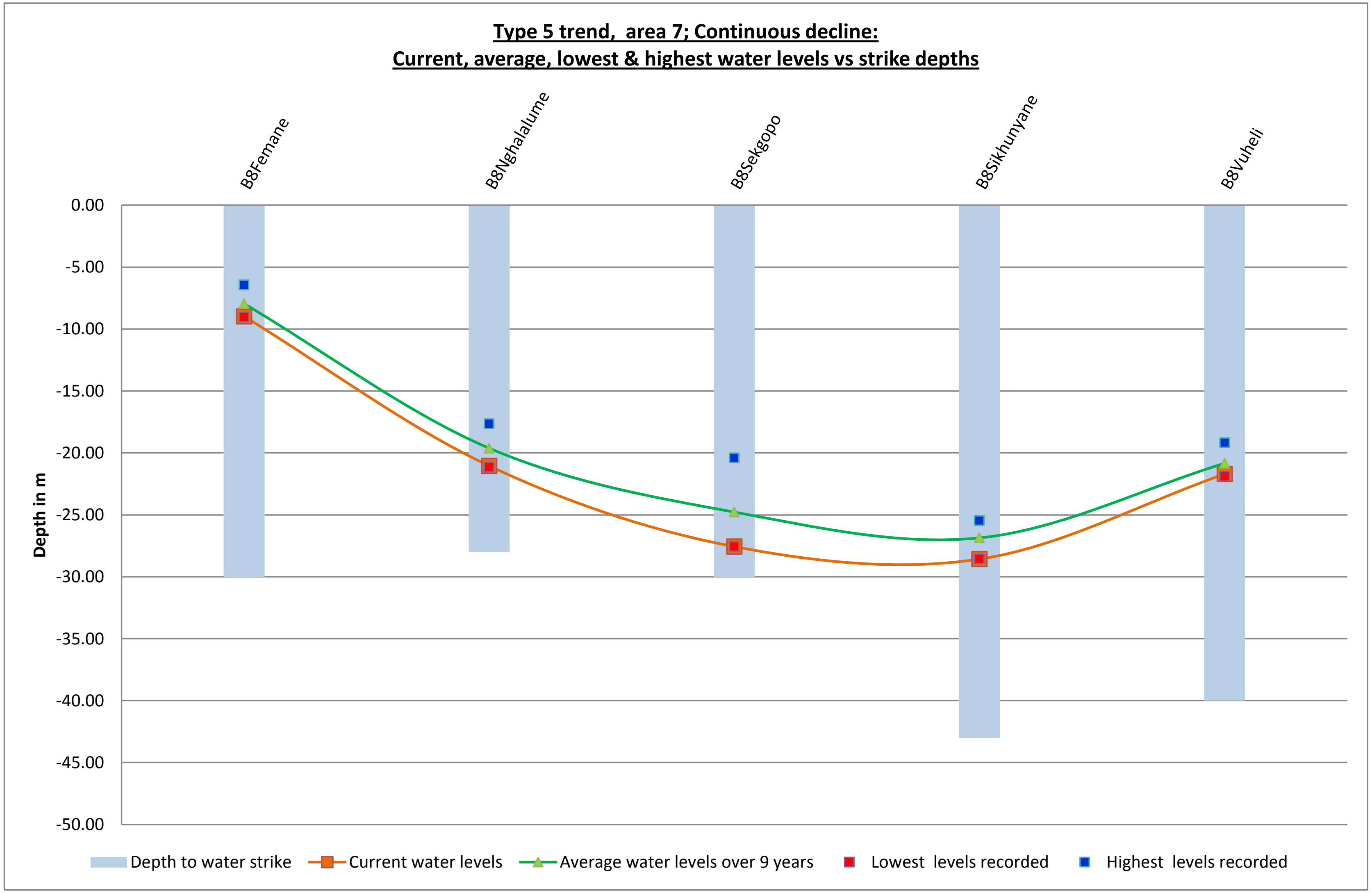
Jul-14
Oct-14
Jan-15
Apr-15
Jul-15
Oct-15
Jan-16
Apr-16
Jul-16
Oct-16
Jan-17
Apr-17
Jul-17
Oct-17
Jan-18
Apr-18
Jul-18
Oct-18
Jan-19
Apr-19
Jul-19
Oct-19
Jan-20
Tom Burke
Water strike
Linear (Tom Burke)

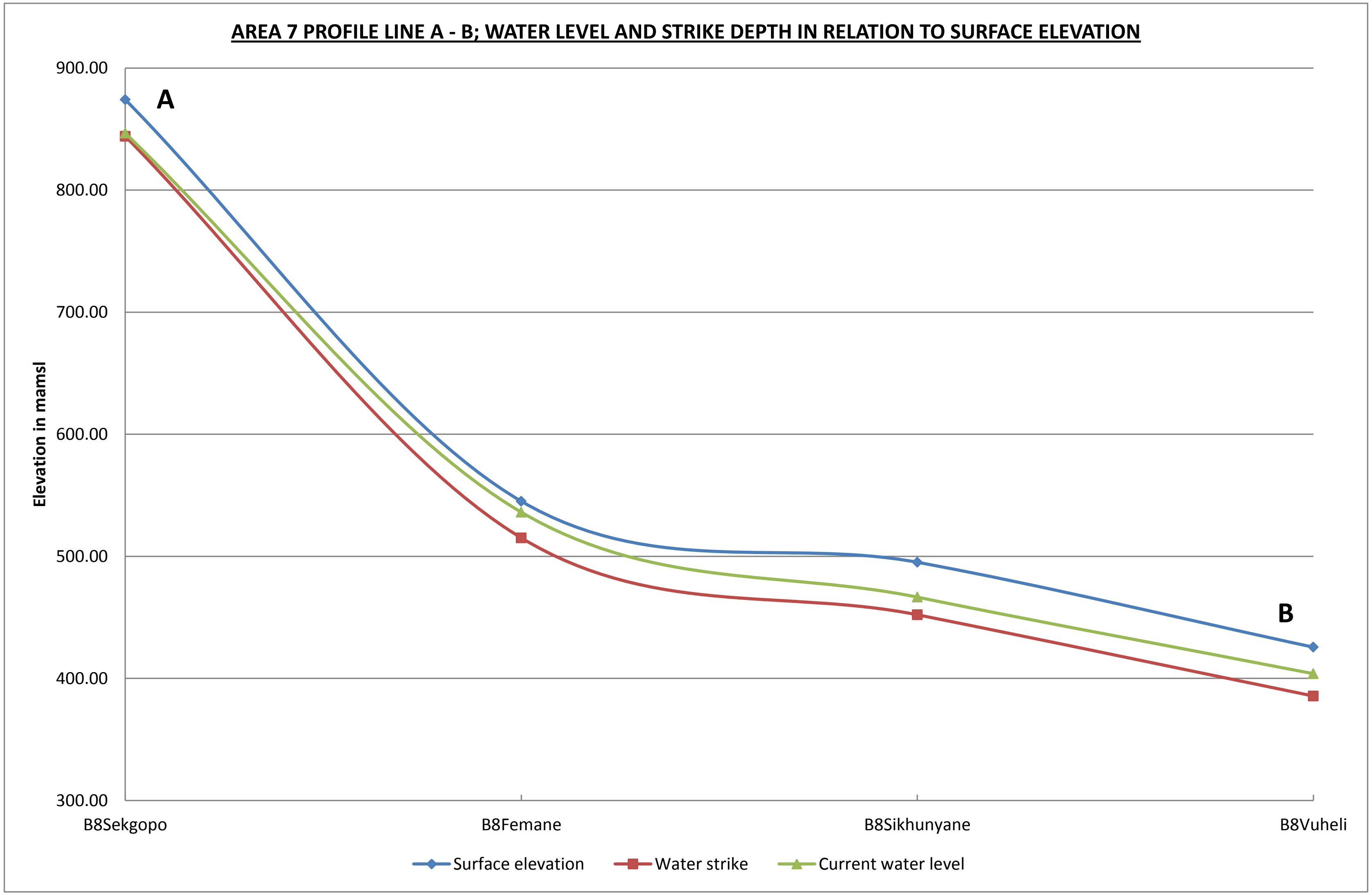
GRAPH 8


Type 5 trend, area 7; Continuous decline:
Current, average, lowest & highest water levels vs strike depths
B8Femane
B8Nghalalume
B8Sekgopo
B8Sikhunyane
B8Vuheli
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
-40.00
-45.00
-50.00
Depth in m
Depth to water strike
Current water levels
Average water levels over 9 years
Lowest levels recorded
Highest levels recorded

GRAPH 9

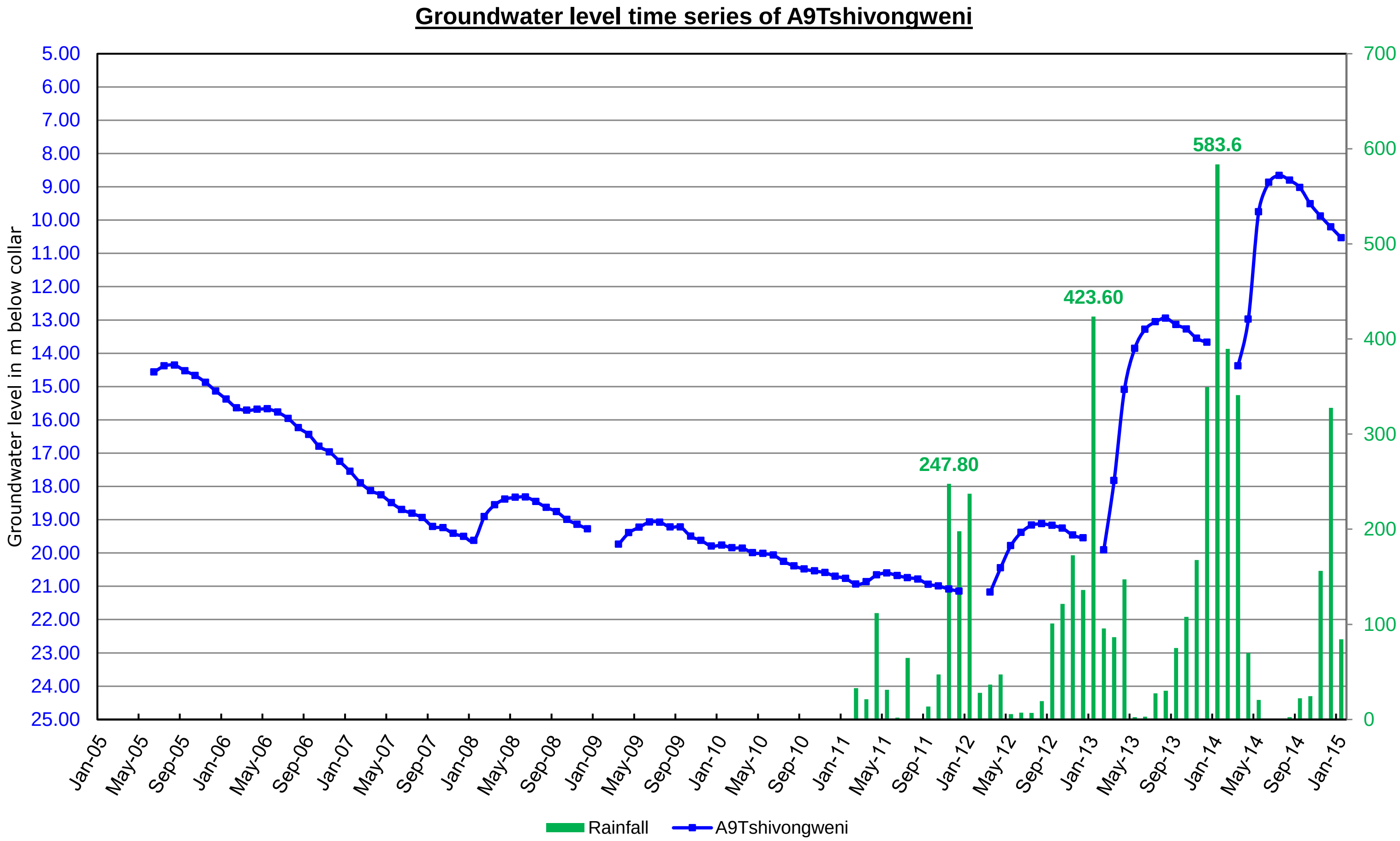

GROUNDWATER LEVEL TREND AT STATION B8 SEKGOPO
Groundwater level in m above collar
20
25
30
35
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
B8 Sekgopo
Depth of water strike
Linear (B8 Sekgopo)

GRAPH 10


AREA 7 PROFILE LINE A - B; WATER LEVEL AND STRIKE DEPTH IN RELATION TO SURFACE ELEVATION
900.00
800.00
700.00
600.00
500.00
400.00
300.00
Elevation in mamsl
A
B
B8Sekgopo
B8Femane
B8Sikhunyane
B8Vuheli
Surface elevation
Water strike
Current water level

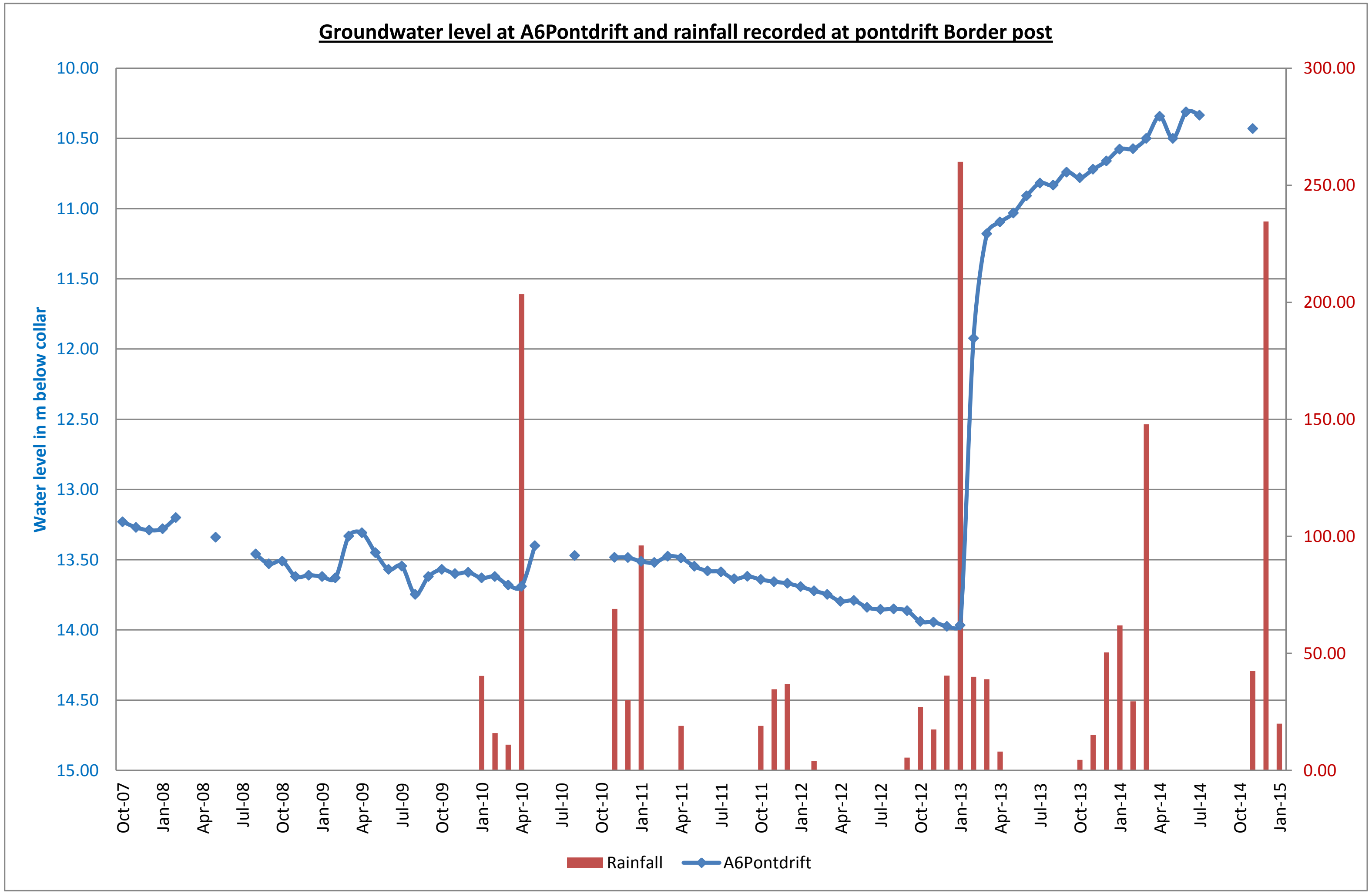
GRAPH 11

EXAMPLE (A) OF TYPE 6 TREND (Long period of decline with good recharge since 2013)

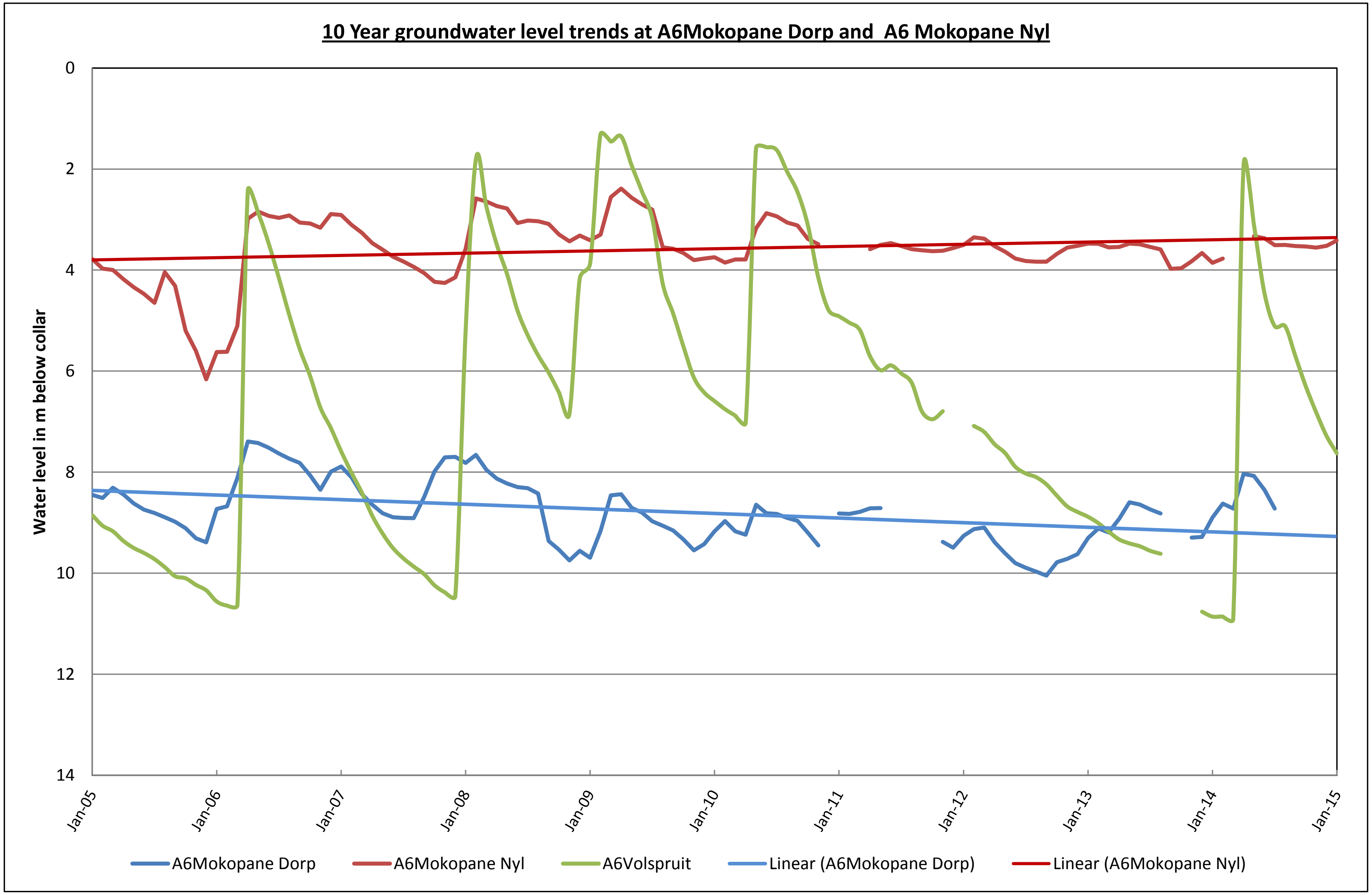


GRAPH 12

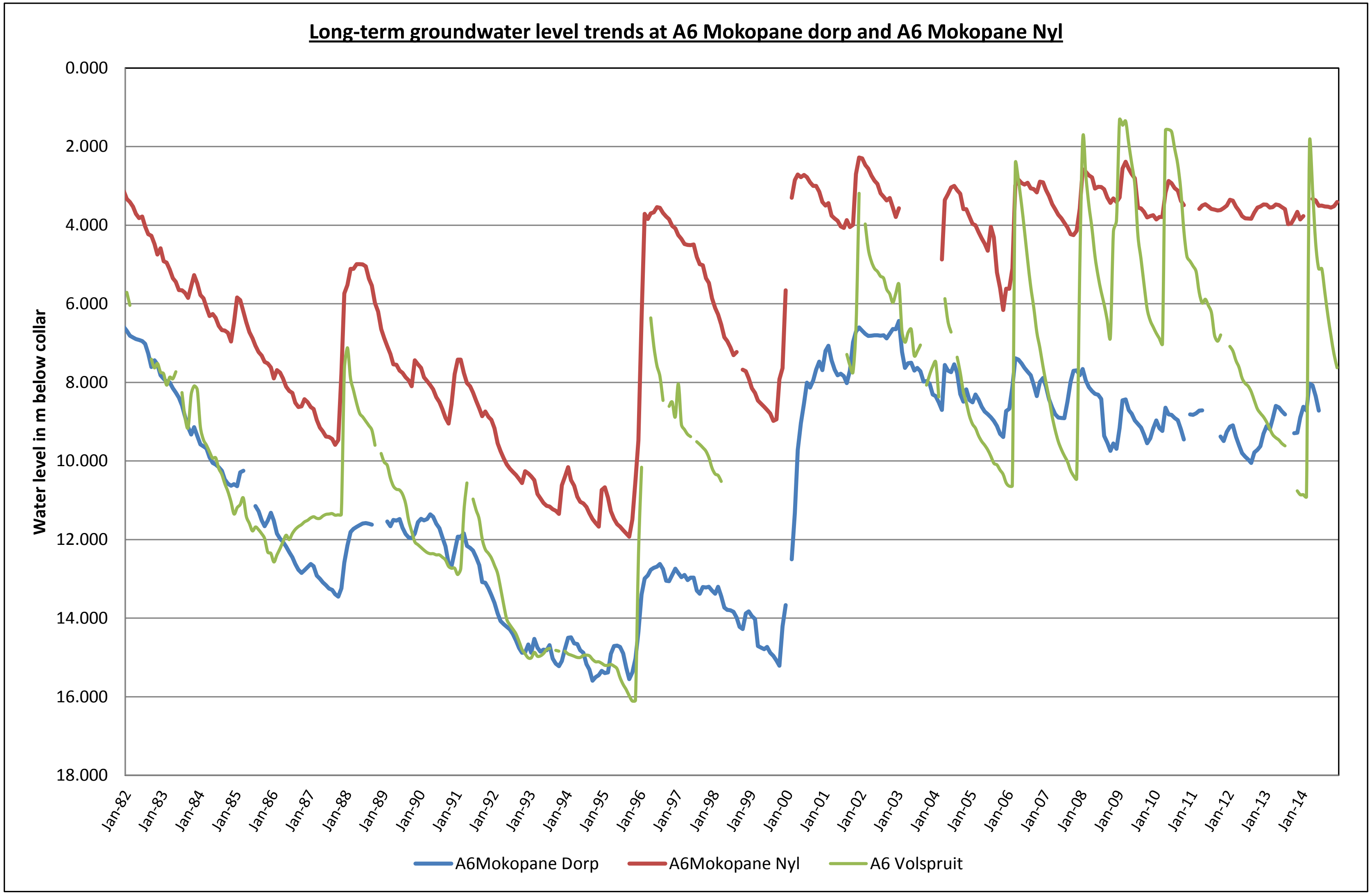
EXAMPLE (B) OF TYPE 6 TREND (Long period of decline with good recharge since 2013)



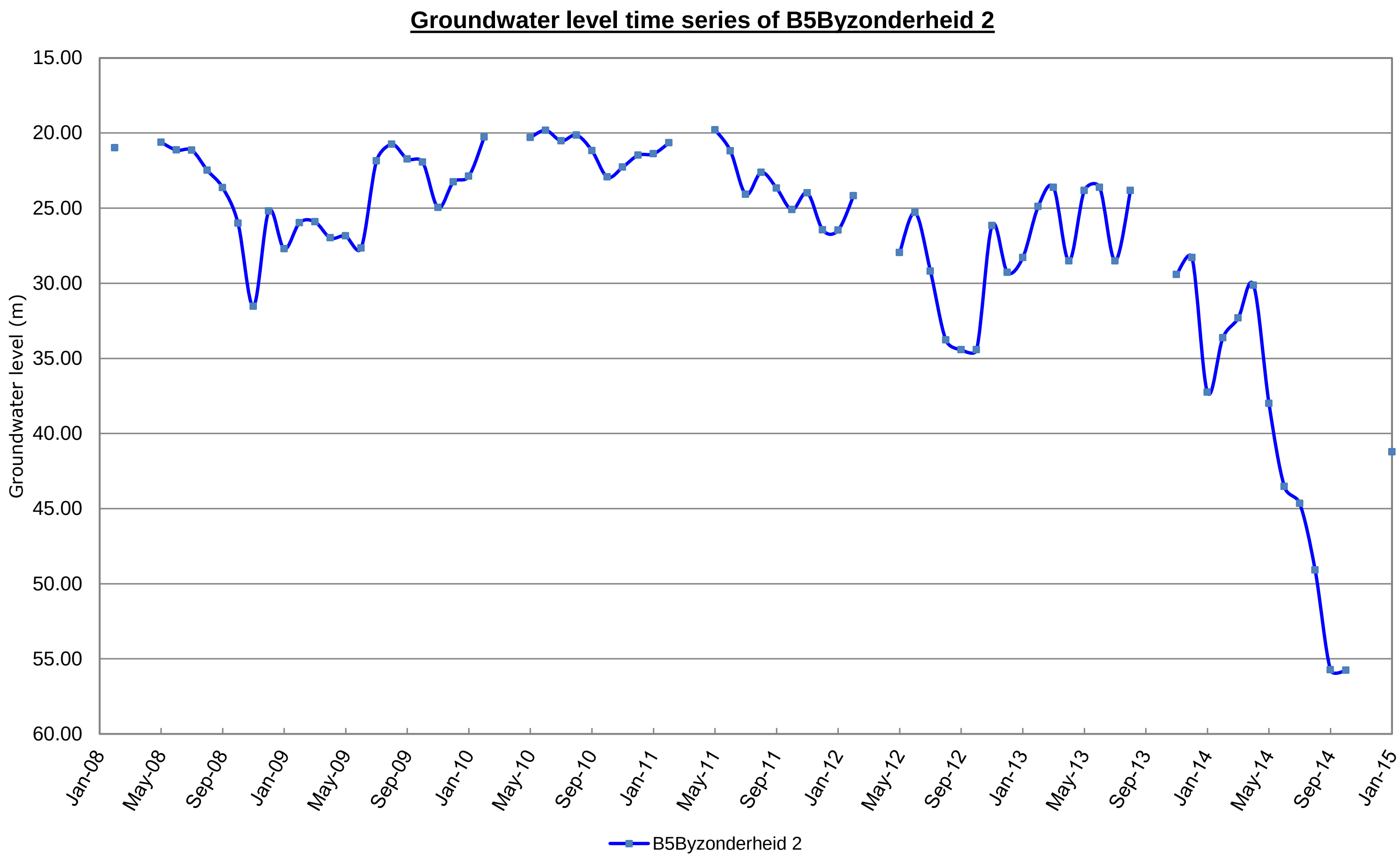
GRAPH 13


10 Year groundwater level trends at A6Mokopane Dorp and A6 Mokopane Nyl
Water level in m below collar
0
2
4
6
8
10
12
14
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
A6Mokopane Dorp
A6Mokopane Nyl
A6Volspruit
Linear (A6Mokopane Dorp)
Linear (A6Mokopane Nyl)

GRAPH 14


Long-term groundwater level trends at A6 Mokopane dorp and A6 Mokopane Nyl
Water level in m below collar
0.000
2.000
4.000
6.000
8.000
10.000
12.000
14.000
16.000
18.000
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
A6Mokopane Dorp
A6Mokopane Nyl
A6 Volspruit

GRAPH 15



Groundwater level time series of B5Byzonderheid 2
Groundwater level (m)
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
Jan-08
May-08
Sep-08
Jan-09
May-09
Sep-09
Jan-10
May-10
Sep-10
Jan-11
May-11
Sep-11
Jan-12
May-12
Sep-12
Jan-13
May-13
Sep-13
Jan-14
May-14
Sep-14
Jan-15
B5Byzonderheid 2

GRAPH 16

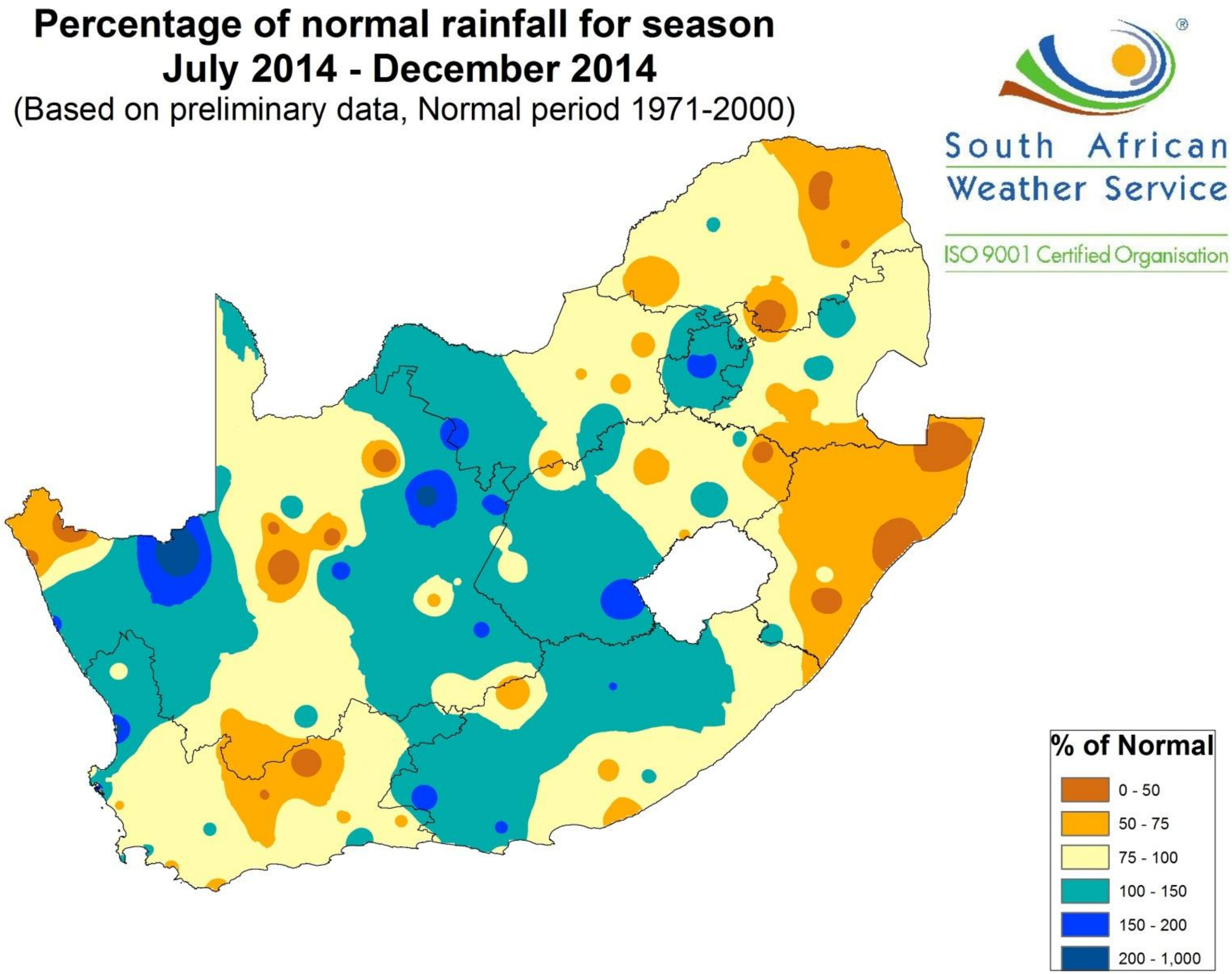

Percentage of normal rainfall for season
July 2014 - December 2014
(Based on preliminary data, Normal period 1971-2000)
South African
Weather Service
ISO 9001 Certified Organisation
% of Normal
0 - 50
50 - 75
75 - 100
100 - 150
150 - 200
200 - 1,000

Figure 1

Environmental Geoscience

Robert Stewart

Environmental Science in the 21st Century – An Online Textbook

WATER ENVIRONMENT

Figure 03

Hydraulic Head in Confined and Unconfined Aquifers

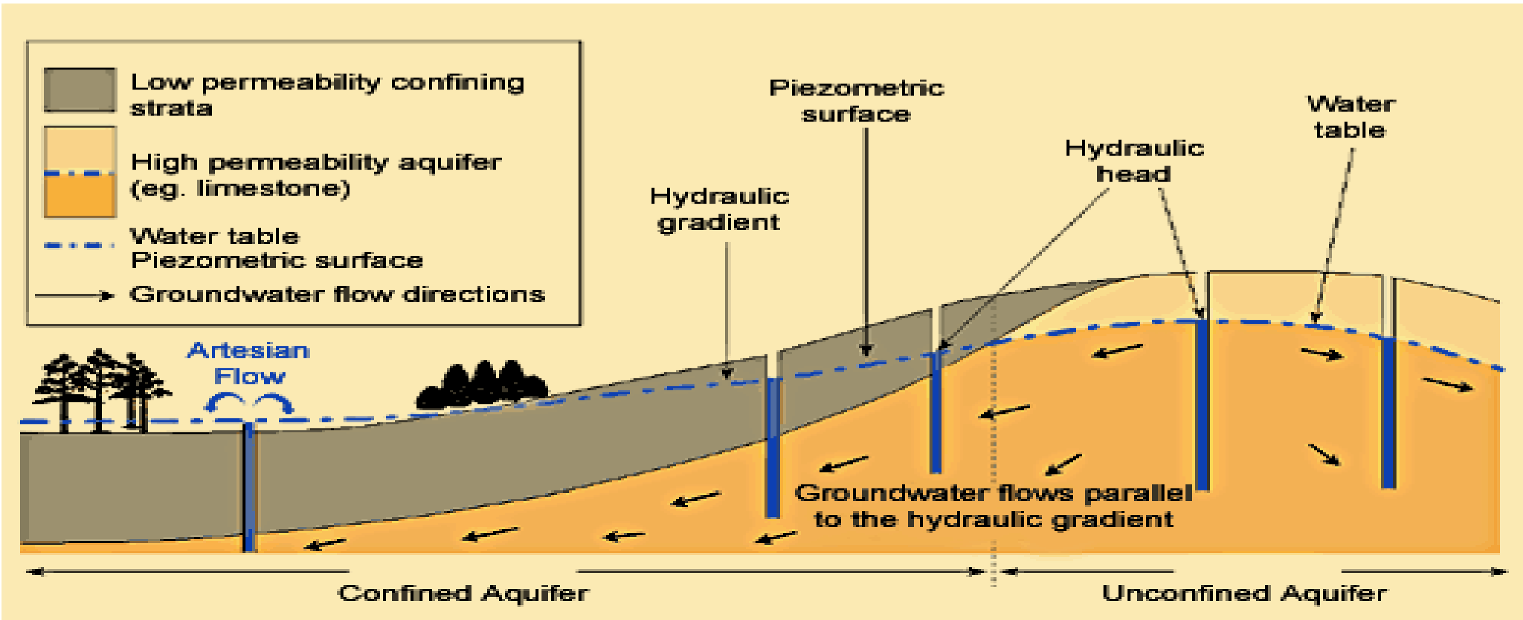


Figure 2