LIMPOPO REGION

QUARTERLY STATUS REPORT ON GROUNDWATER LEVEL TRENDS

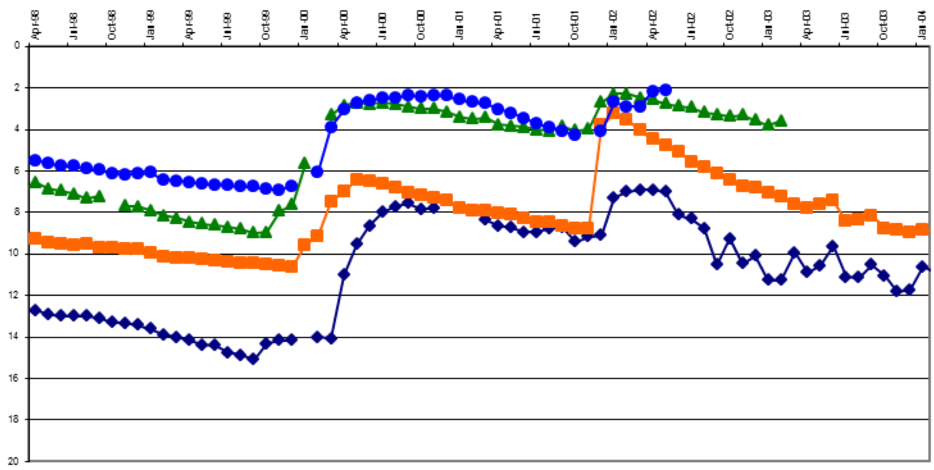

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TABLE OF CONTENTS

LIST OF MAPS

LIST OF GRAPHS

LIST OF FIGURES

LIST OF TABLES

SUMMARY

The status of groundwater levels discussed in the report reflects the situation as on 31 December 2015 which represents the end of the first hydrological quarter and also the middle of the rainy season.
Most of southern Africa is currently experiencing extreme drought conditions with the lowest rainfall in fifty years reported for South Africa by the South African Weather Services. The effect of drought on groundwater is not as visible and immediate as on surface resources but can be just as devastating in time.
No drastic declining groundwater levels can be attributed to the drought at this stage. At the majority of monitoring stations the normal seasonal fluctuations is observed. The total lack of recharge so far for the season is prominent and account for the 89.9% of groundwater levels monitored, currently being lower than the corresponding time last year.
Long-term groundwater level trends indicate that, despite the short-term declining trend, current groundwater level status is generally still good. Areas characterised by regular seasonal recharge indicates that the normal seasonal loss can be recovered in a short period of time following high precipitation. If good rain occurs in the latter part of the season, groundwater in such areas may still recover sufficiently to weather the upcoming dry season. Forecasts at this stage is however not favourable. Should the dry weather persist and no recharge occurs, the normal dry season decline will start with groundwater levels already much lower than usual. The effect of the drought on groundwater may then in time become a concern and even critical, depending on how long the drought continues.
Current available groundwater level and rainfall data indicate that recharge in some areas do not follow normal seasonal rainfall. Three such areas were identified were no recharge is indicated for some years now and water levels constantly keep declining even through the wet seasons. The recharge mechanisms in these areas evidently require above normal rainfall events to facilitate recharge. Unfortunately there is no long-term groundwater level data available for any of these areas to enable better assessment of the current status. Data is only available for eight to ten years. The fact that the rainfall received the past eight to ten years, of which some seasons were very high rainfall seasons, caused no recharge is a concern. The lack of recharge and constant declining water levels makes groundwater in these areas vulnerable.

Exceptions will always be present, in this case drastically declining groundwater levels and failing of production holes due to lack of resource management leading to over abstraction. Such cases identified thus far are still limited to localised occurrences but never the less critical to those affected.

As surface water resources diminishes the dependency on groundwater increases. The current drought and the uncertainty of future climate and rainfall emphasize the critical need for effective management of this resource.

1. BACKGROUND

1 October to 31 December is the first quarter of the hydrological year and represents the first half of the wet season. Electronic groundwater level data was downloaded and processed during January and February 2016. Rainfall data was sourced from the South African Weather Services.

Comparison is drawn between the current situation and the start of the wet season as well as with the corresponding time the previous year in the different secondary drainage areas. A better perspective on the current status is provided by the long-term trend displayed at some of the monitoring stations but the lack of long-term water level data in some areas do constitute a challenge.

Rainfall data is unavailable for large areas of the Province. Rainfall data used to correlate with responses in groundwater may not always be the relevant data for a specific station but is used due to the lack of any other data. An attempt is always made to use the nearest rainfall station upstream of a monitoring station but is not always possible. Rainfall can vary considerable over short distances which may make some data used irrelevant in the response, or lack thereof, observed in groundwater.

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

2. GROUNDWATER LEVELS

While the objective of the monitoring network is to monitor un-impacted groundwater levels as far as possible. The widespread abstraction renders this virtually impossible as most sites are impacted to some extent. Establishing of new production boreholes lead to some monitoring stations being directly affected by pumping. In calculation of averages for tables 1 and 2 those stations directly affected by nearby abstraction were not included.

The percentages displayed in the tables below represent the percentage of stations with data for both dates in question.

2.1. DIFFERENCE IN GROUNDWATER LEVELS; 1 OCTOBER TO 31 DECEMBER 2015 (TABLE 1)

The lack of recharge during the first half of the wet season is clearly displayed by the 82.95% of monitoring stations with water levels still lower than at the start of the wet season. The average decline is 0.56m over the 3 months. Only 15.9% indicate higher water levels over the period with an average rise of 0.29m.
The distribution of monitoring stations with higher or lower groundwater levels is illustrated by **MAP 2**.

1 October to 31 December 2015	
Total stations	188

With data	176 Stations	93.6%

Water level	Number of stations	Average(m)	%
Down	146 Stations	-0.56 m	82.95%
Up	28 Stations	0.29 m	15.91%
No change	2 Stations		1.14%
No Data	12 Stations		100.00%

TABLE 1

2.2 DIFFERENCE IN GROUNDWATER LEVELS; 31 DECEMBER 2014 TO 31 DECEMBER 2015 (TABLE 2)

89.9% of the monitoring stations indicated lower water levels than the corresponding time last year. The average decline is 1.68m. Higher water levels were only indicated at 10% of the monitoring stations with an average rise of 0.5m.
The distribution of monitoring stations with higher or lower groundwater levels is illustrated by **MAP 3**

31 December 2014 to 31 December 2015	
Total stations	188

With data	168 Stations	89.4%

Water level	Number of stations	Average(m)	%
Down	151 Stations	1.68 m	89.88%
Up	17 Stations	0.51 m	10.12%
No change	0 Stations		0.00%
No Data	20 Stations		100.00%

TABLE 2

3 GROUNDWATER LEVEL TRENDS IN THE DIFFERENT SECONDARY DRAINAGE AREAS

The groundwater levels at different stations within each secondary drainage area were compared as indication of the current status with regard to previous years. The distribution of groundwater level monitoring stations as well as rainfall stations used for compilation of the graphs is indicated on **MAP 4.**

3.1 DRAINAGE AREAS A4 AND A5

Groundwater levels of all stations in the two drainages for December 2014 and 2015 is illustrated by **GRAPH 1.** From the graph it can be noted that only one station, A4Vaalwater, has a higher water level in 2015. The water level has been slowly but constantly rising with no seasonal fluctuation over the past six years since monitoring started there. No definite reason can be offered but it is considered to be linked to the deep water strike at 112 m and a very low yield and thus low transmissivity. Confined aquifer and artesian conditions is common in the area and the groundwater level at this station may still be rising to the real piezometric head.

3.1.1 DRAINAGE A4

Groundwater levels in the lower reaches of the drainage are virtually un-impacted due to the land use pattern and indicate stable conditions with little fluctuation. Clear seasonal fluctuations are normally present in the upper recharge area as indicated on **GRAPH 2.**
Graph 2 indicates regular seasonal recharge usually notable by December and subsequent decline in water levels after the wet season. Despite that the current groundwater levels not being considered to be a reason for concern the lack of recharge thus far are. The recharge normally apparent by December is totally lacking. If recharge does not occur in the last quarter of the wet season the normal dry season decline would start from much lower levels than usual. The real impact of the drought on groundwater will then only become apparent over time.

3.1.2 DRAINAGE A5

The general trend of groundwater levels in this drainage is a constant slow decline. No recharge is apparent at most stations over more than five years since monitoring started here. Rainfall recorded during this period seems to be inadequate to facilitate recharge **GRAPH 3.** A very slight increase in the rate of decline can be noted at A5Zwartwater2 but otherwise no effect of the current drought can be seen on the already declining water levels. It is not known what magnitude of rainfall incident would be needed for real recharge to occur but such an event is clearly needed.

3.2 DRAINAGE A6

There is a large number of groundwater monitoring stations in this drainage and the groundwater levels of all stations for December 2014 and 2015 is illustrated by **GRAPH 4.** Groundwater levels at most are lower than last year and of the few with higher levels some are related to variable pumping effects at the time the data was collected and some represent levels returning from exceptional highs.
The same seasonal pattern as discussed for the A4 drainage can be noted here. The groundwater level time series and rainfall at A6Rykdom is included as an example **GRAPH 5.** The continuous decline since last season with no recharge as yet is very apparent. Although the status is still good currently, with no recharge before the start of the dry season levels will keep declining from an already low.
Groundwater levels in the north western part of the drainage correspond with that of the A5 drainage characterized by a steady decline and no apparent recharge **GRAPH 6.** A major recharge event is also needed for the groundwater levels to recover.
In the far northern part of the drainage good recharge occurred during the 2012-2013 season and groundwater levels rose to exceptional highs at some localities **GRAPH 7.** Levels have been declining since last season but are currently still high and the effect of the lack of recharge would take longer to raise concern than elsewhere.

3.3 DRAINAGE A7

This drainage also have a large number of groundwater monitoring stations and the groundwater levels of all stations for December 2014 and 2015 is illustrated by **GRAPH 8.**
The trends displayed on **GRAPH 9** indicate stable to even rising conditions with regular seasonal fluctuation of the groundwater levels over the last 8 to 9 years. The 2013 -- 2014 wet season indicates good recharge with declining levels again to the 2014 – 2015 wet season when recharge was even better. The subsequent declines correspond with the previous ones except for the lack of recharge thus far. Again, although not a matter of concern yet, the drought effect will only become clear in time.
As with the A6 drainage, did good rainfall and recharge occur in the part north of the Soutpansberg in this drainage and some groundwater levels are still at, or returning from exceptional highs. **GRAPH 10** serves as an example

3.4 DRAINAGE A8 AND A9

Groundwater levels of all stations in the A8 and A9 drainages for December 2014 and 2015 is illustrated by **GRAPH 11.** All levels are lower than the previous year.

3.4.1 DRAINAGE A8

While all other groundwater level trends in this drainage display both a stable or rising trend and regular seasonal recharge, station A8Mabvete indicates a steady decline with virtually no sign of recharge since

2008 **GRAPH 12**. The trend corresponds with some trends discussed for the A5 and A6 drainages but the reason is not clear. Rainfall data for the area is unfortunately not available but a major recharge event is probably needed to recharge this area.
The groundwater levels at some stations immediately north of the Soutpansberg not only indicate the good recharge event for the 2012 – 2013 season as is the case for the northern part of the A6 and A7 drainages, but also for the 2008 – 2009 season **GRAPH 13.** Water levels in this area are also starting to decline but currently still high.
The general stable trends displayed for the A8 drainage is indicated on **GRAPH 14.**
Current status is generally good.

3.4.2 DRAINAGE A9

Some groundwater levels are also still declining after exceptional high levels were reached during the 2012 – 2013 season and currently still high as illustrated on the example graph; **GRAPH 15**
Most of the A9 drainage has been characterised by steady declining groundwater levels since 2006 when monitoring started in the area. Unfortunately the recharge from the 2012 – 2013 season was not enough for the groundwater levels to recover completely in the whole drainage, especially in the north eastern part, and current levels are still lower than in 2006 **GRAPH 16.** This area is drained by the Mutale and Mbodi Rivers. In such areas the impact of the drought will be more severe and become apparent much sooner. As with similar instance already mentioned, it is not known what magnitude of rainfall event is needed for good recharge but such an event is needed.
Groundwater levels in the southern part of the A9 drainage drained by the Levhuvhu and Mutshindudi rivers are generally stable with regular seasonal recharge **GRAPH 17**. Recharge normally notable by the end of December is thus far absent and if no recharge occurs effect of the current drought on groundwater will become apparent in time.

3.5 DRAINAGES B3, B4, B5 AND B7

The above drainage areas has a small number of monitoring stations in each and grouped together to limit the number of graphs. Groundwater levels of all stations in the four drainages for December 2014 and 2015 is illustrated by **GRAPH 18.**

3.5.1 DRAINAGE B3

Abstraction impact on the areas of two of the monitoring stations is severe and it is impossible to make any evaluation of the natural trends **GRAPH 19.** Groundwater was severely under stress from 2002 to 2008 after which it was allowed to recover. Since 2011 abstraction impact can be noted and current levels are below that of 1995 after a prolonged period of severe drought.
The other two monitoring stations in this drainage are not directly affected by abstraction and display a constant declining trend **GRAPH 20.** Current levels are not considered a matter for concern yet but recharge is needed. Rainfall recorded the past five years did not seem to cause any recharge and local recharge may not be the recharge mechanism or the intensity of rainfall events were not high enough.

3.5.2 DRAINAGE B4

There is only one monitoring station in this drainage the groundwater level of which is very stable with the current level 1 m higher than in 2005 when monitoring was started. Graph not included.

3.5.3 DRAINAGE B5

Groundwater level trends in the B5 drainage can generally be described as stable with regular seasonal recharge and discharge patterns. In the Sekhukhune area there is an underlying slow trend present **GRAPH 21.** Current levels re not considered a concern yet but if the current drought continues for a prolonged period of time the rate of decline would increase and groundwater levels may reach unacceptable levels.
Long-term groundwater level trends as displayed by stations monitoring the dolomitic aquifers serves as an example of the general trend **GRAPH 22.** Stable water levels with a healthy current status are displayed on the graph.

One exception occurs in this drainage and will be discussed under point **7: (The importance of groundwater monitoring and resource management)**

3.5.4 DRAINAGE B7

Stable conditions since 2006 when monitoring started is indicated **GRAPH 23.** Some good recharge occurred in April 2014 but very little the following year causing mostly declining levels since then and no recharge this season as yet. Groundwater levels are still considered to be in a healthy state currently. As with all other areas, if the drought persists the impact will become notable in time.

3.6 DRAINAGES B8 AND B9

Groundwater levels of all stations in the two drainages for December 2014 and 2015 is illustrated by **GRAPH 24.** As is the general case elsewhere, are all groundwater levels currently lower than the previous year.

3.6.1 DRAINAGE B8

Two distinct trends are displayed by the groundwater levels in the A8 drainage. One in the northern part drained by the Koedoes, Klein and Middel Letaba Rivers, quaternary B82, and a second one in the southern part drained by the Great Letaba River system, quaternary B81,before the confluence with Klein Letaba.
Trends displayed by groundwater levels in the northern part indicate steady long-term decline and virtually no evidence of recharge **GRAPH 25.**
GRAPH 26 on the other hand indicates stable conditions with normal seasonal fluctuations in water levels. A two year decline can be noted since April 2014 which corresponds with a similar 2-year period of decline from 2011 t0 2013. The only difference being that the recharge at the end of the period is lacking at this stage and levels are already below that of February 2013.

3.6.2 DRAINAGE B9

There are only four monitoring stations in the B9 drainage and groundwater levels at all indicate an underlying slow decline as the adjoining B8 drainage to the south. The very high rainfall event of 2013 did not have much impact here.

4 LONG-TERM PERSPECTIVE

Unfortunately is long-term groundwater level data not available for many monitoring stations and available long-term data is restricted to three small areas. In the absence of long-term data in an area it is very difficult to really assess the current status. Comparison of short to medium term trends with that where long-term data is available is used to identify similar groundwater behaviour. The assumption is made that if short to medium term trends correspond the same may be truth for past periods in time.

4.1 LONG-TERM GROUNDWATER LEVEL TRENDS AT A6N0044 (MOKOPANE DORP) AND A6N0079 (A6MOKOPANE NYL) AS WELL AS SOME STATIONS IN THE A7 DRAINAGE GRAPHS 28 AND 29

The effect of previous periods of drought, especially during the eighties and early nineties, can be noted. The stable fluctuating levels since 2000 are similar to that displayed by many stations around Limpopo. The normal seasonal decline and no evident recharge this season as yet were discussed above for almost all areas in Limpopo. Despite this, the current status here is still good. If it assumed that this may be true in other areas where the same trends are displayed by available data, the status of most groundwater levels is still good at this stage

5 RAINFALL

5.1 PERCENTAGE OF NORMAL RAINFALL; JULY 2015 TO JANUARY 2016

FIGURE 1 complied by the South African Weather Services indicates that most of Limpopo received less than 75% and even less than 50% in the eastern half of the province up to January 2016
A separate document “South Africa total annual rainfall” by the South African Weather Services is distributed with this report for more information on annual rainfall

6 SEASONAL FORECAST

Detail on forecasts compiled by the South African Weather Services “Seasonal climate watch” is distributed with this report.

7 IMPORTANCE OF GROUNDWATER MONITORING AND RESOURCE MANAGEMENT

The current drought condition is impacting on groundwater as well but not as visible as on surface water. The effect is also delayed but just as serious in the long run. The immediate impact on surface water leads to more consideration given to groundwater as a source. The sustainable use of groundwater depends, as with any resource, on sound management. The basis for groundwater management lay in monitoring with regard to abstraction volumes, water level trends and quality.

7.1 GROUNDWATER LEVEL TREND AT A7N0660 (A7LANGJAN)

The area where this monitoring is located is subjected to large-scale abstraction. The impact can be clearly seen on **GRAPH 30.** From the rapid decline in groundwater level it is clear that continuous abstraction at the current rate cannot be sustainable.

7.2 GROUNDWATER LEVEL TREND AT B5BYZONDERHEID 2

The Groundwater level at this station has declined by 42 m since August 2013. The station is located in the municipal area of Roedtan. The town is currently experiencing a water shortage due to failed boreholes.

8 AREAS WHERE GROUNDWATER IS CONSIDERED TO BE MOST VULNERABLE TO DROUGHT

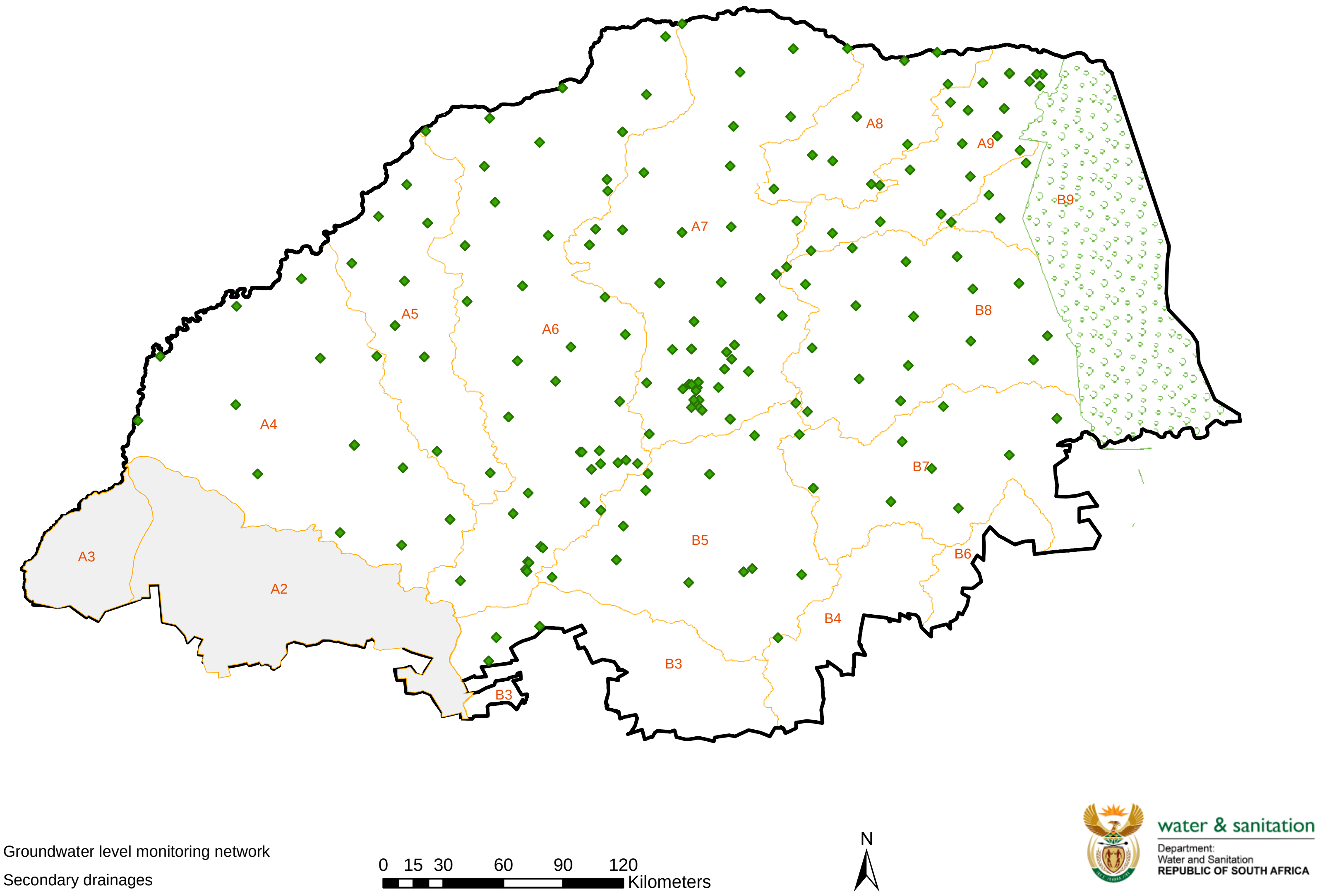
Monitoring stations characterised by constant declining groundwater levels and no apparent recharge for some time now were identified from trend graphs. The identified monitoring stations are located in three discernable areas and are depicted on **MAP 5.** Seasonal percentage of rainfall maps compiled by the

South African Weather Services reveal that since 2009 these areas received below normal rainfall in two seasons, 2011 to 2012 and again in the 2014 to 2015. For the other five seasons rainfall ranged from normal to above normal. It is considered that areas not recharged by normal seasonal rainfall but depend on major recharge events may be more vulnerable to the impact of prolonged drought.

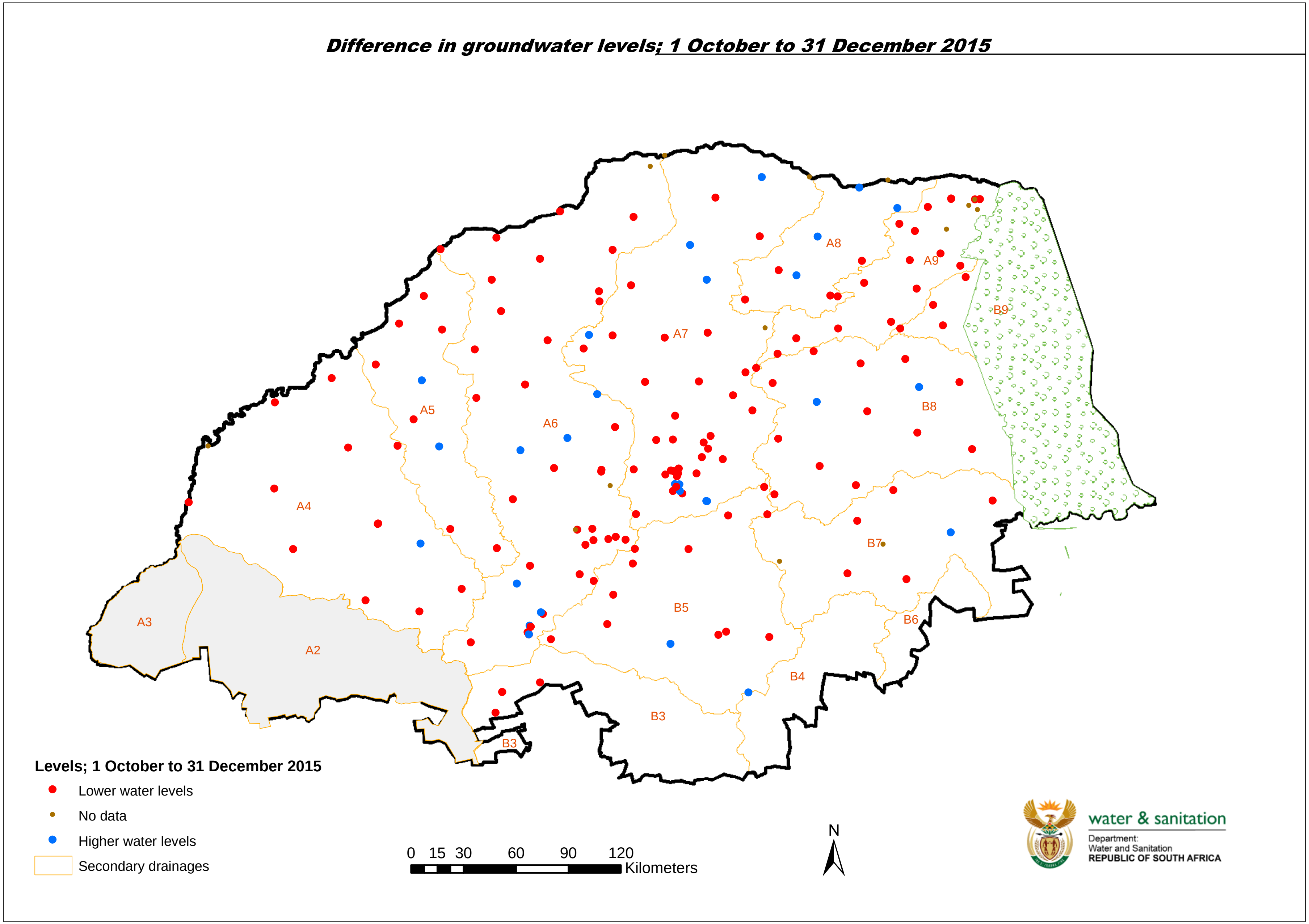
9 ACKNOWLEDGEMENTS

Percentage of normal rainfall:
South African Weather Services: http://www.weathersa.co.za

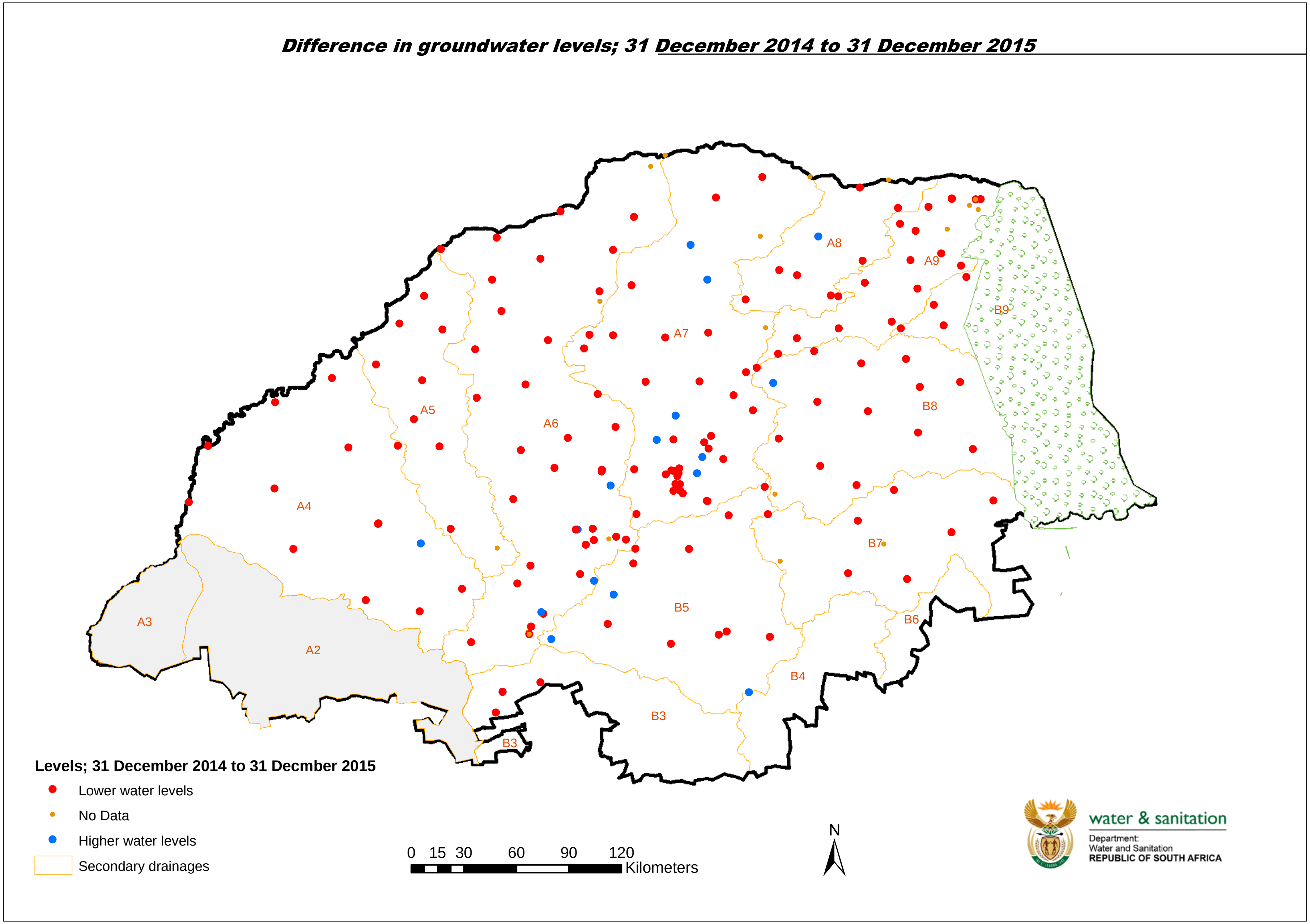
Distribution of the groundwater level monitoring network in the Limpopo Province



MAP 1

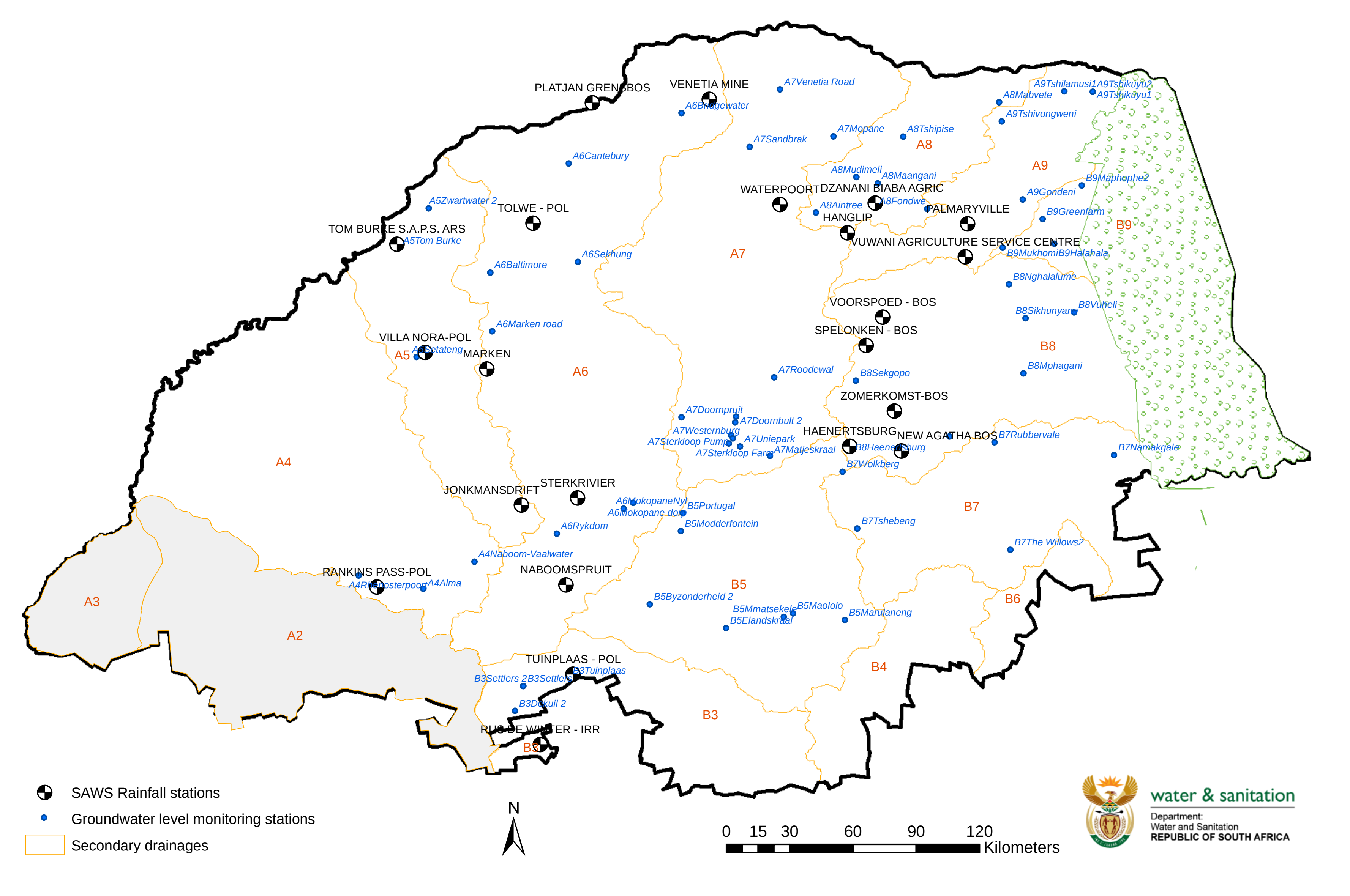

Difference in groundwater levels; 1 October to 31 December 2015
A2
A3
A4
A5
A6
A7
A8
A9
B3
B4
B5
B6
B7
B8
B9
Levels; 1 October to 31 December 2015
Lower water levels
No data
Higher water levels
Secondary drainages
0 15 30 60 90 120
Kilometers
N
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

MAP 2


Difference in groundwater levels; 31 December 2014 to 31 December 2015
A2
A3
A4
A5
A6
A7
A8
A9
B3
B3
B4
B5
B6
B7
B8
B9
Levels; 31 December 2014 to 31 Decmber 2015
Lower water levels
No Data
Higher water levels
Secondary drainages
0 15 30 60 90 120
Kilometers
N
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

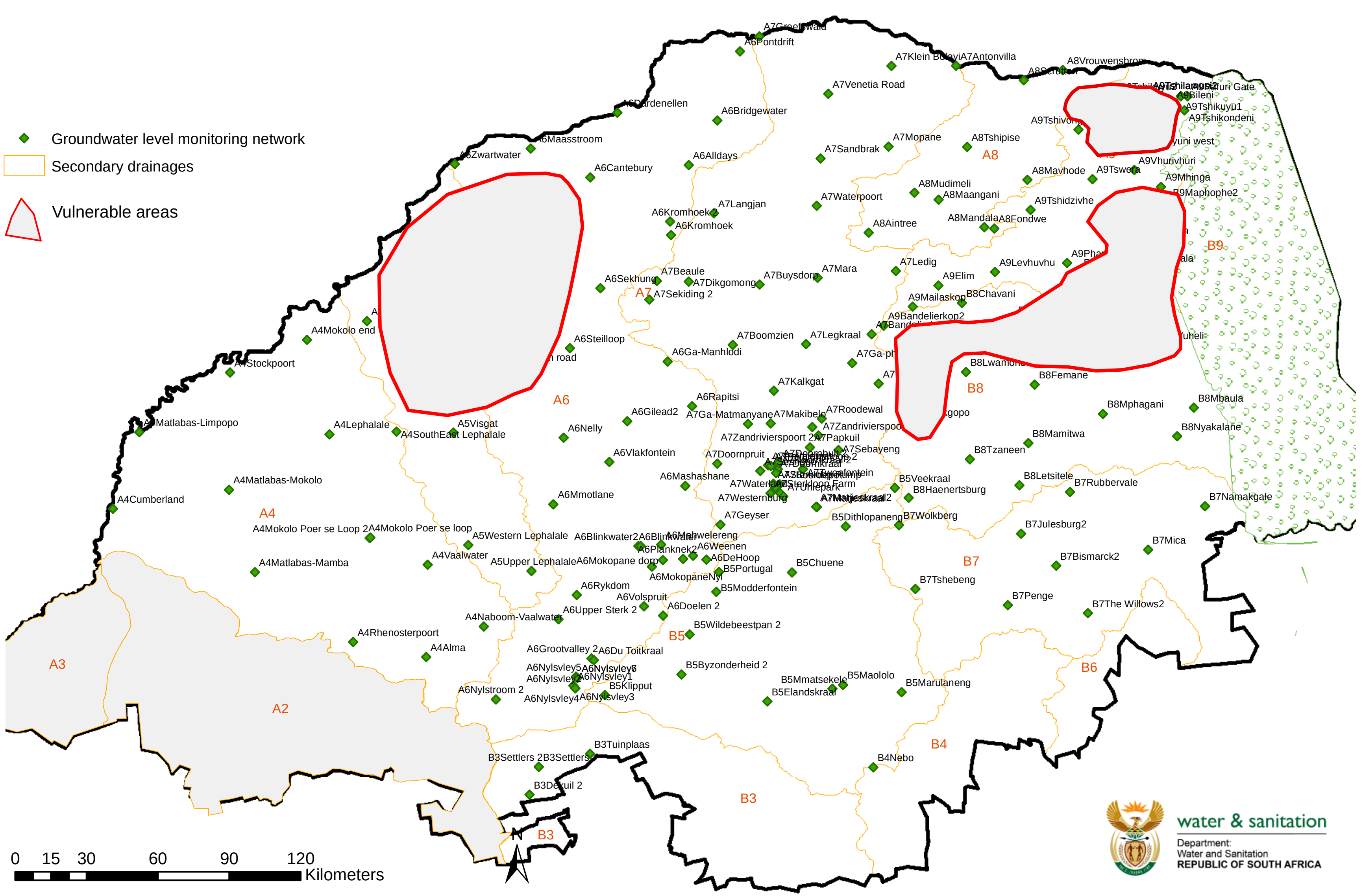
MAP 3

Distribution of Rainfall and groundwater monitoring stions used in example graphs

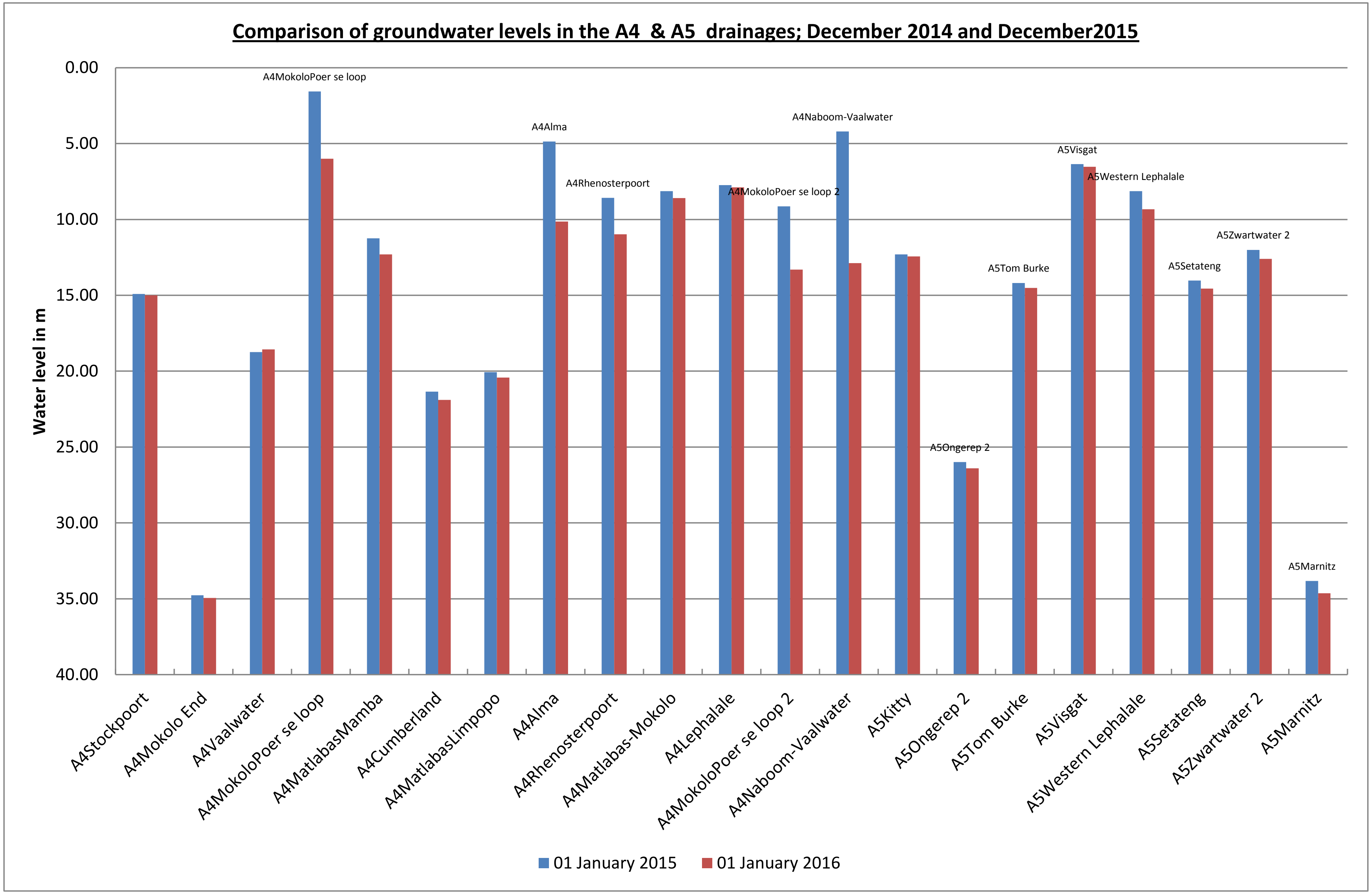


MAP 4

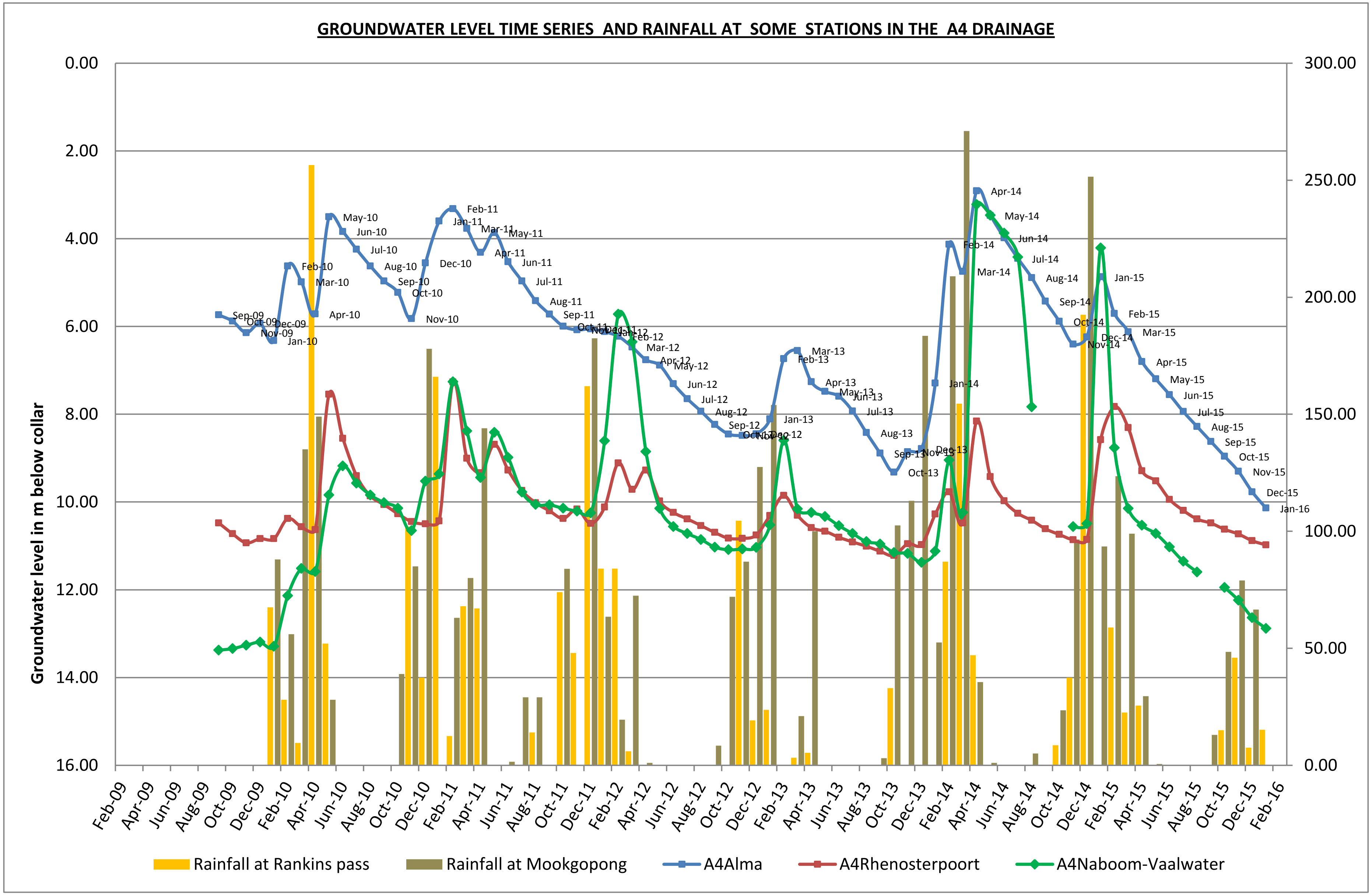
Areas where groundwater may be most vulnerable to drought



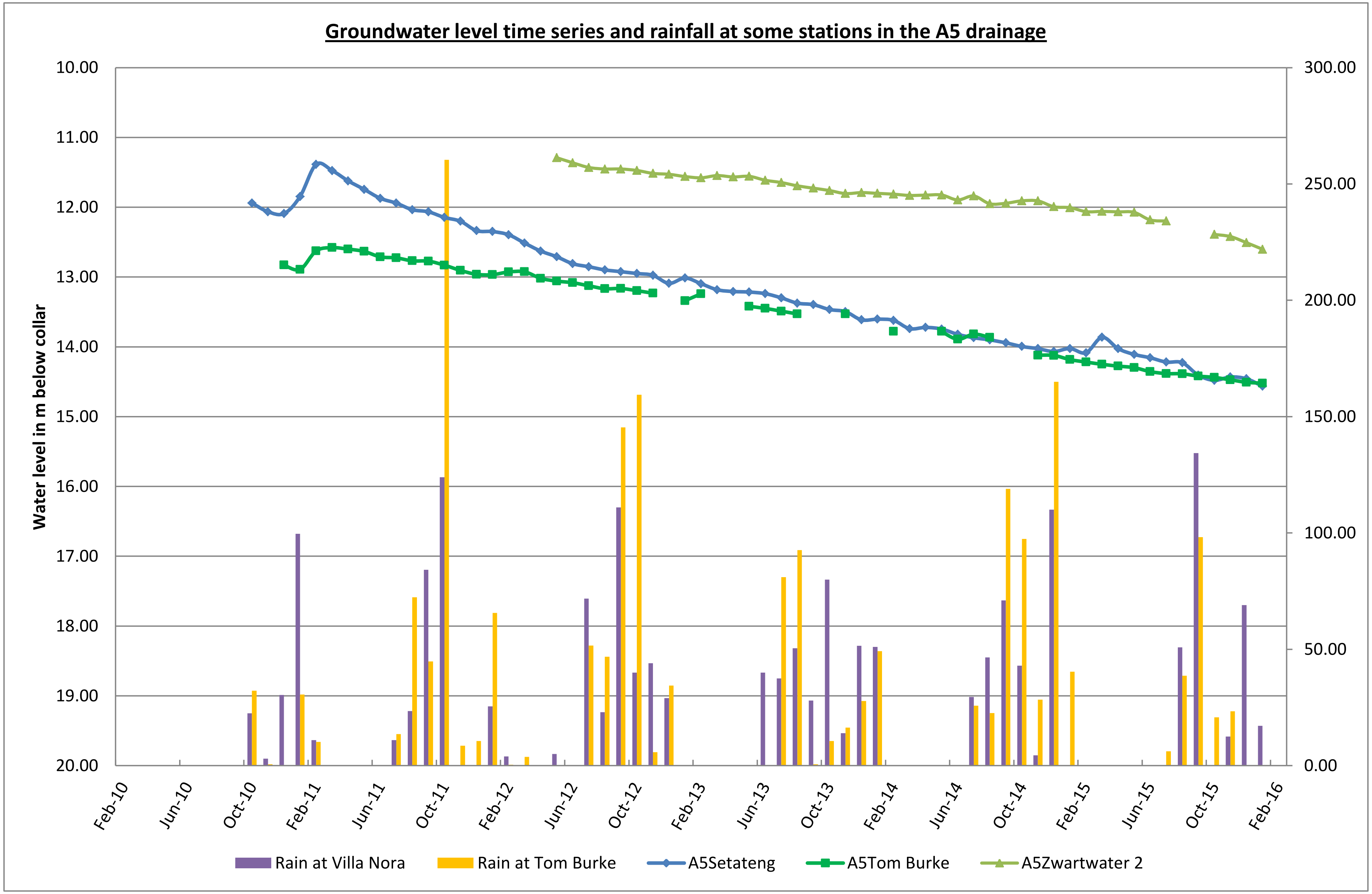
MAP 5


Comparison of groundwater levels in the A4 & A5 drainages; December 2014 and December2015
Water level in m
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
A4MokoloPoer se loop
A4Alma
A4Rhenosterpoort
A4MokoloPoer se loop 2
A4Naboom-Vaalwater
A5Ongerep 2
A5Tom Burke
A5Visgat
A5Western Lephalale
A5Setateng
A5Zwartwater 2
A5Marnitz
A4Stockpoort
A4Mokolo End
A4Vaalwater
A4MokoloPoer se loop
A4MatlabasMamba
A4Cumberland
A4MatlabasLimpopo
A4Alma
A4Rhenosterpoort
A4Matlabas-Mokolo
A4Lephalale
A4MokoloPoer se loop 2
A4Naboom-Vaalwater
A5Kitty
A5Ongerep 2
A5Tom Burke
A5Visgat
A5Western Lephalale
A5Setateng
A5Zwartwater 2
A5Marnitz
01 January 2015
01 January 2016

GRAPH 1

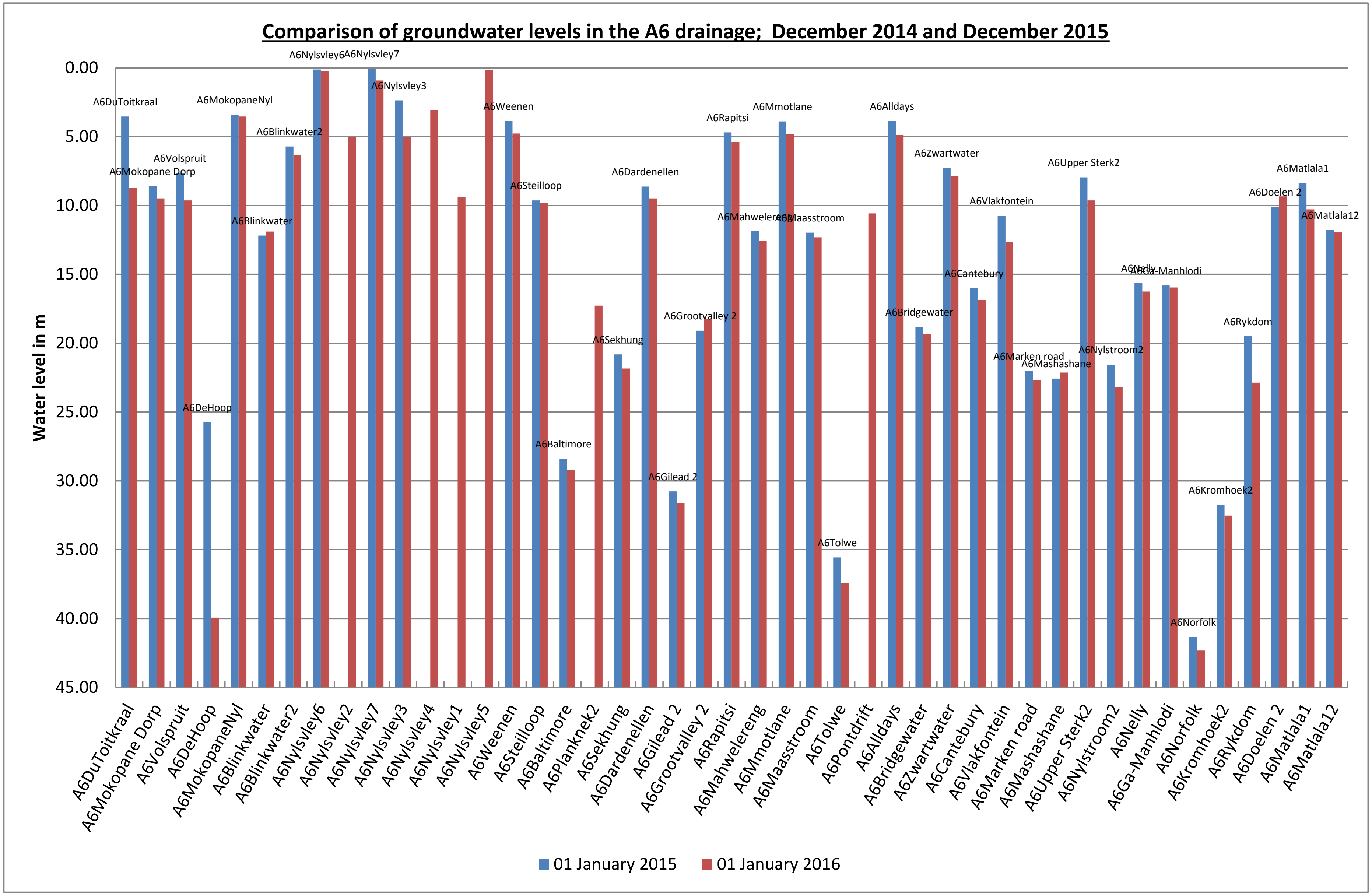

GROUNDWATER LEVEL TIME SERIES AND RAINFALL AT SOME STATIONS IN THE A4 DRAINAGE
Groundwater level in m below collar
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Feb-09
Apr-09
Jun-09
Aug-09
Oct-09
Dec-09
Feb-10
Apr-10
Jun-10
Aug-10
Oct-10
Dec-10
Feb-11
Apr-11
Jun-11
Aug-11
Oct-11
Dec-11
Feb-12
Apr-12
Jun-12
Aug-12
Oct-12
Dec-12
Feb-13
Apr-13
Jun-13
Aug-13
Oct-13
Dec-13
Feb-14
Apr-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
Rainfall at Rankins pass
Rainfall at Mookgopong
A4Alma
A4Rhenosterpoort
A4Naboom-Vaalwater

GRAPH 2



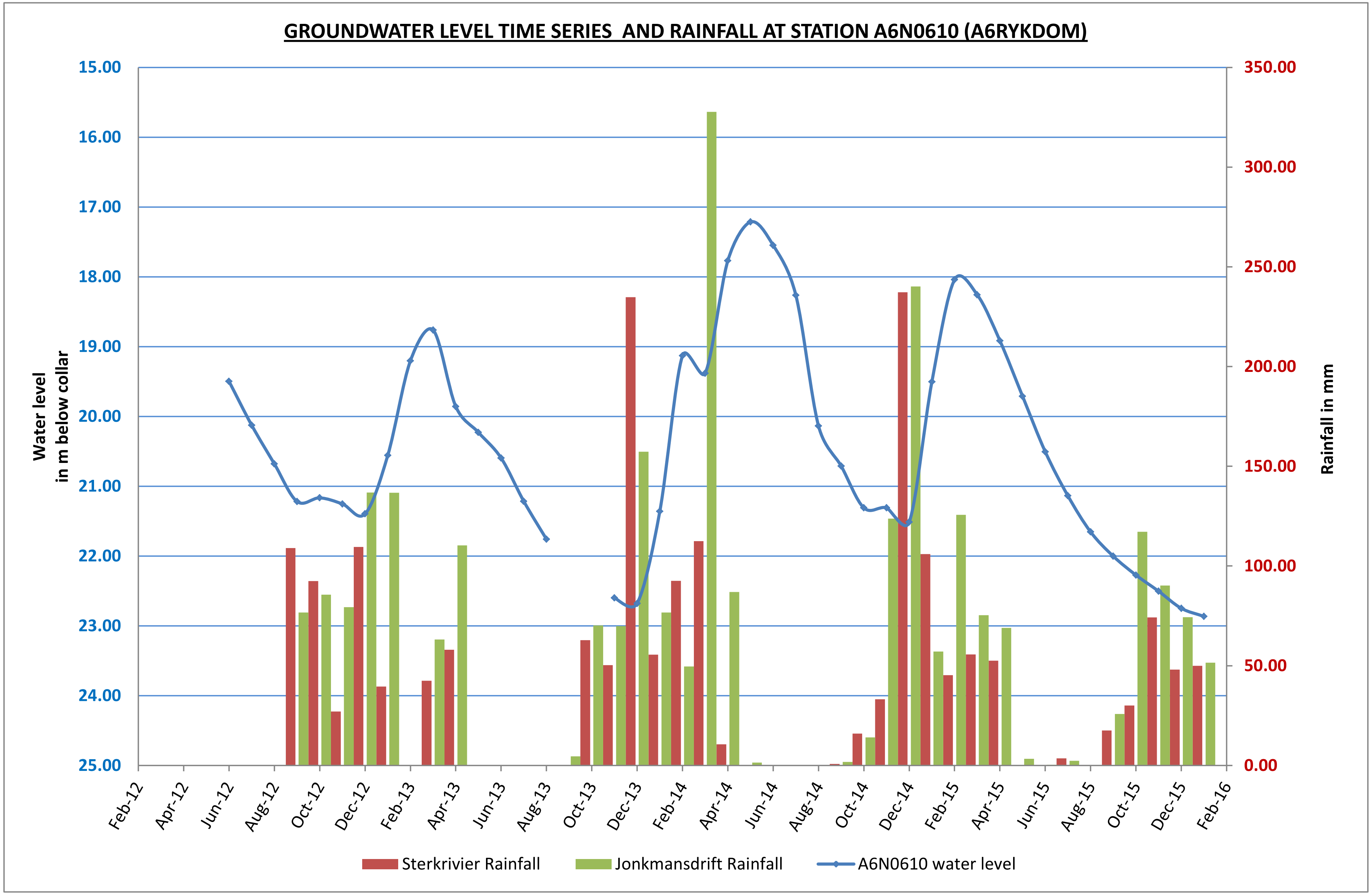
Groundwater level time series and rainfall at some stations in the A5 drainage
Water level in m below collar
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
Rain at Villa Nora
Rain at Tom Burke
A5Setateng
A5Tom Burke
A5Zwartwater 2

GRAPH 3



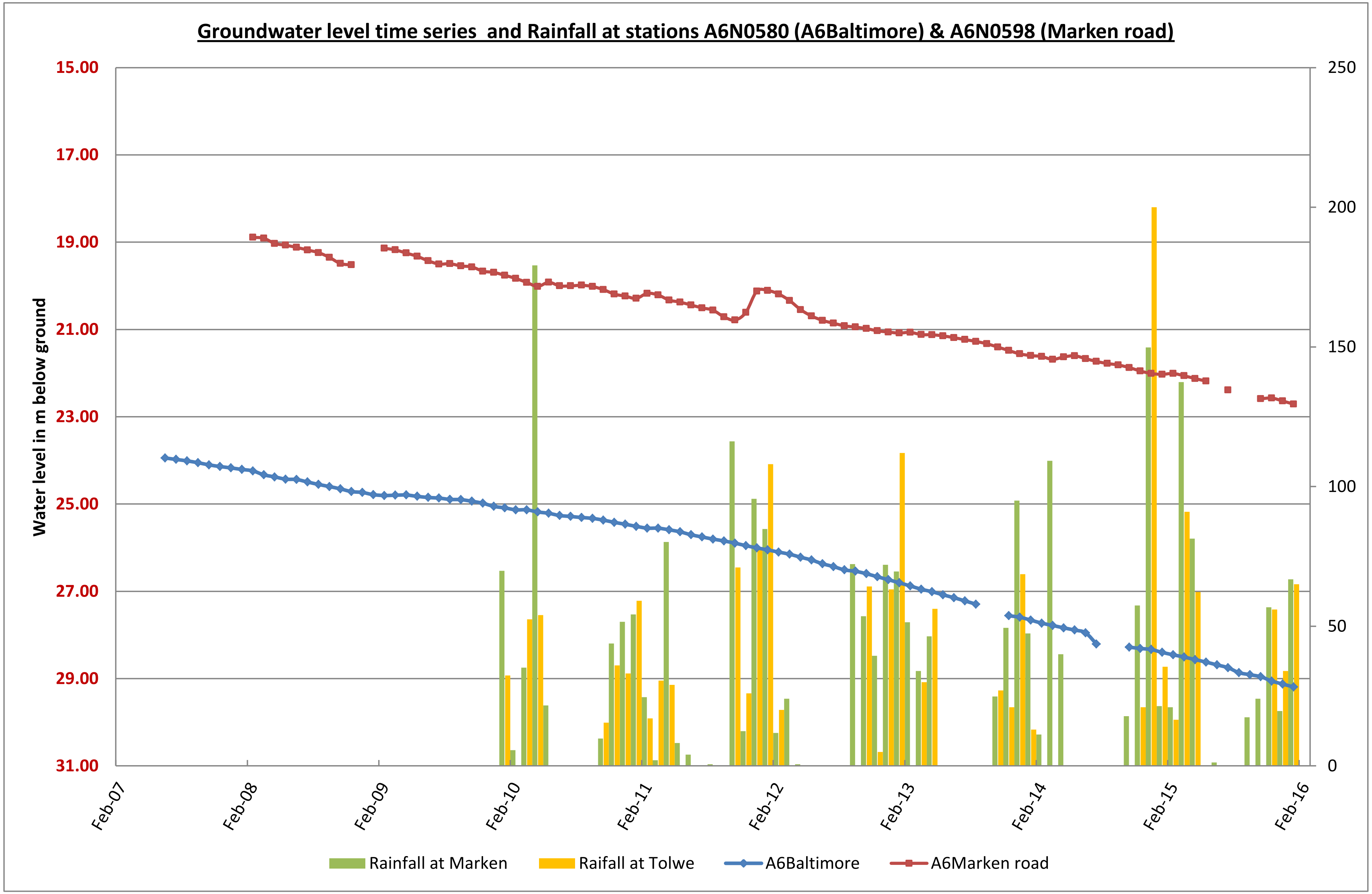
Comparison of groundwater levels in the A6 drainage; December 2014 and December 2015
Water level in m
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
A6DuToitkraal
A6Mokopane Dorp
A6Volspruit
A6DeHoop
A6MokopaneNyl
A6Blinkwater
A6Blinkwater2
A6Nylsvley6
A6Nylsvley2
A6Nylsvley7
A6Nylsvley3
A6Nylsvley4
A6Nylsvley1
A6Nylsvley5
A6Weenen
A6Steilloop
A6Baltimore
A6Planknek2
A6Sekhung
A6Dardenellen
A6Gilead 2
A6Grootvalley 2
A6Rapitsi
A6Mahwelereng
A6Mmotlane
A6Maasstroom
A6Tolwe
A6Pontdrift
A6Alldays
A6Bridgewater
A6Zwartwater
A6Cantebury
A6Vlakfontein
A6Marken road
A6Mashashane
A6Upper Sterk2
A6Nylstroom2
A6Nelly
A6Ga-Manhlodi
A6Norfolk
A6Kromhoek2
A6Rykdom
A6Doelen 2
A6Matlala1
A6Matlala12
01 January 2015
01 January 2016

GRAPH 4



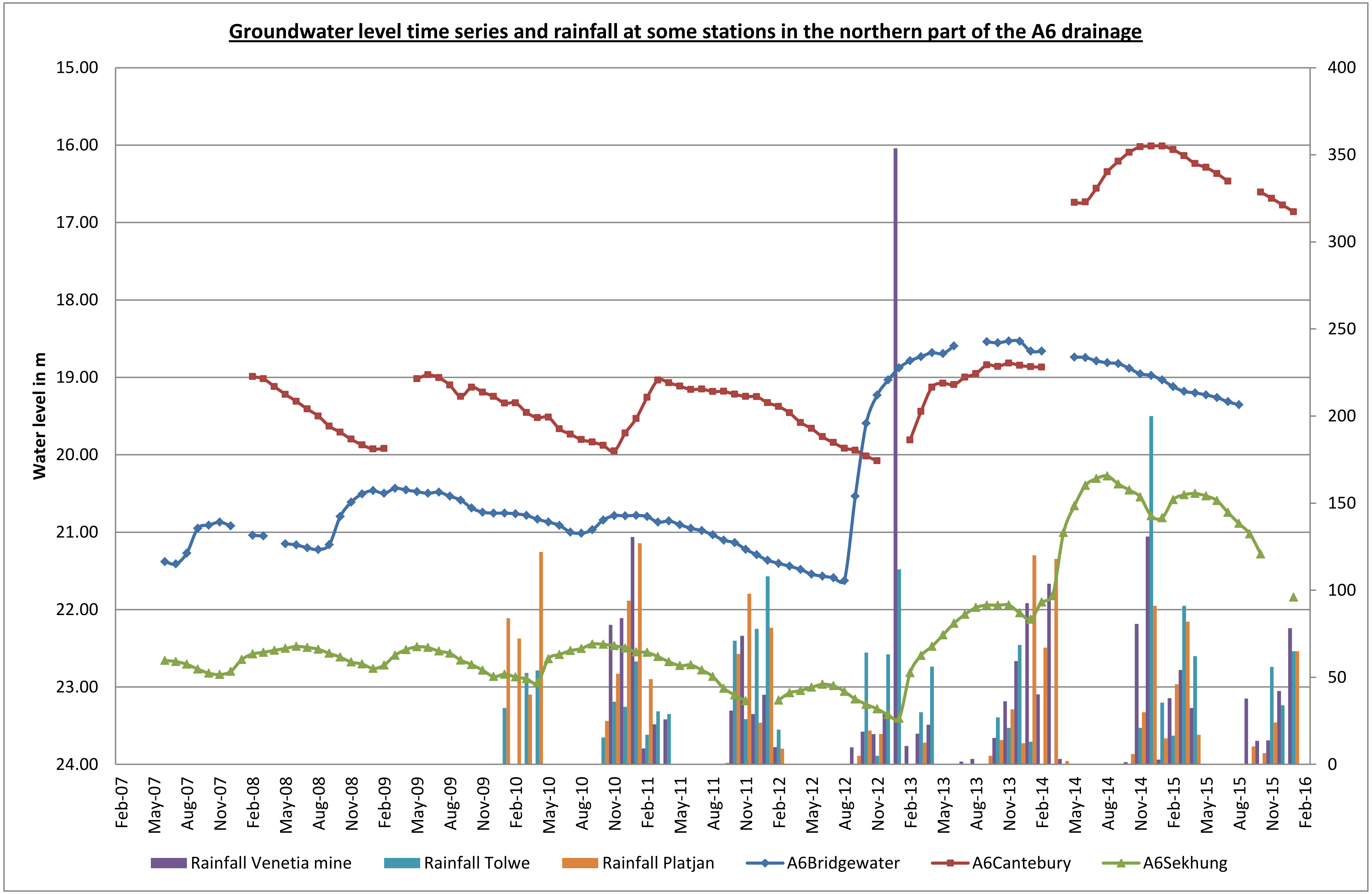
GROUNDWATER LEVEL TIME SERIES AND RAINFALL AT STATION A6N0610 (A6RYKDOM)
Water level in m below collar
Rainfall in mm
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Feb-12
Apr-12
Jun-12
Aug-12
Oct-12
Dec-12
Feb-13
Apr-13
Jun-13
Aug-13
Oct-13
Dec-13
Feb-14
Apr-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
Sterkrivier Rainfall
Jonkmansdrift Rainfall
A6N0610 water level

GRAPH 5

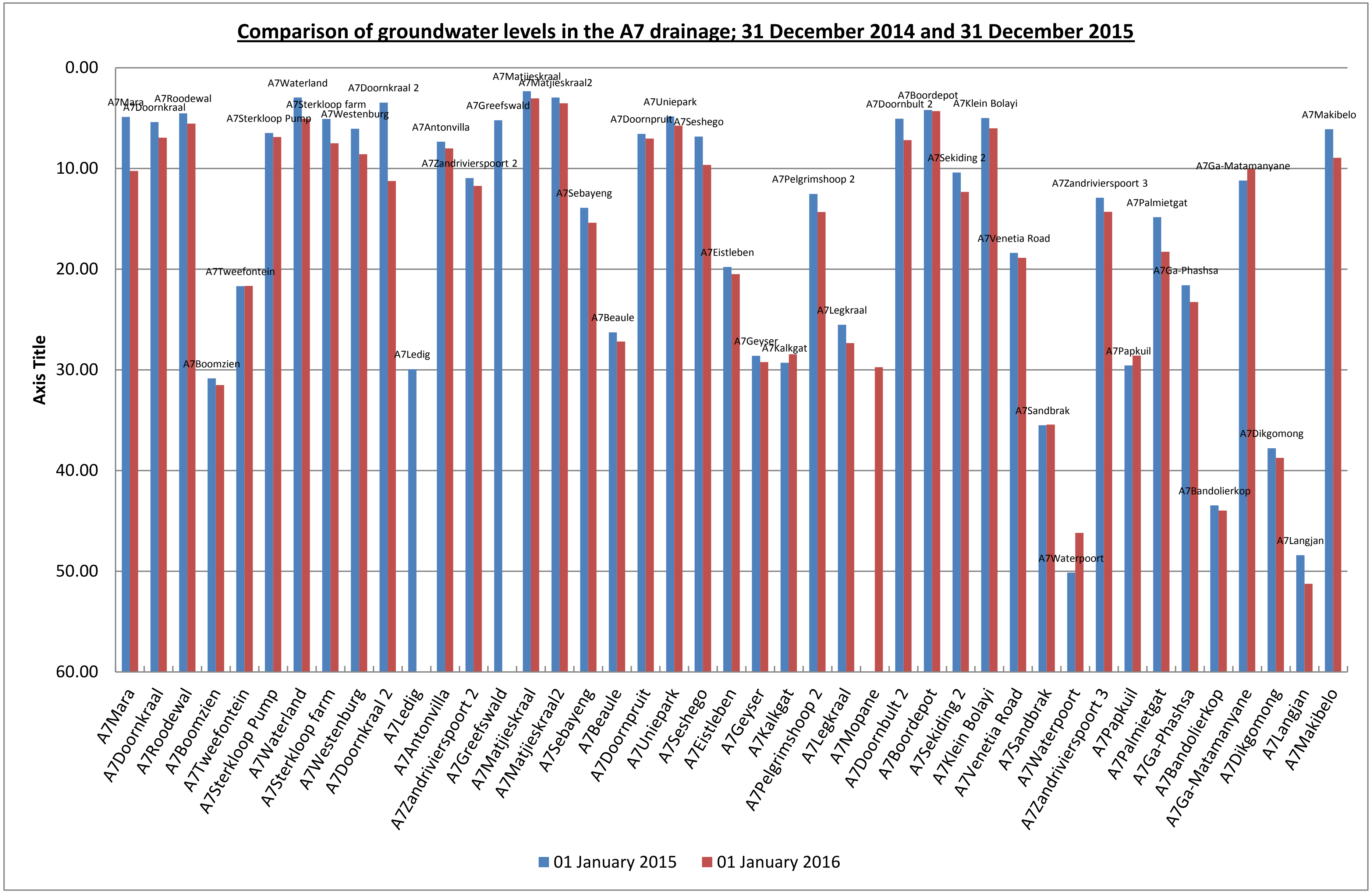


Groundwater level time series and Rainfall at stations A6N0580 (A6Baltimore) & A6N0598 (Marken road)
Water level in m below ground
15.00
17.00
19.00
21.00
23.00
25.00
27.00
29.00
31.00
250
200
150
100
50
0
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
Rainfall at Marken
Raifall at Tolwe
A6Baltimore
A6Marken road

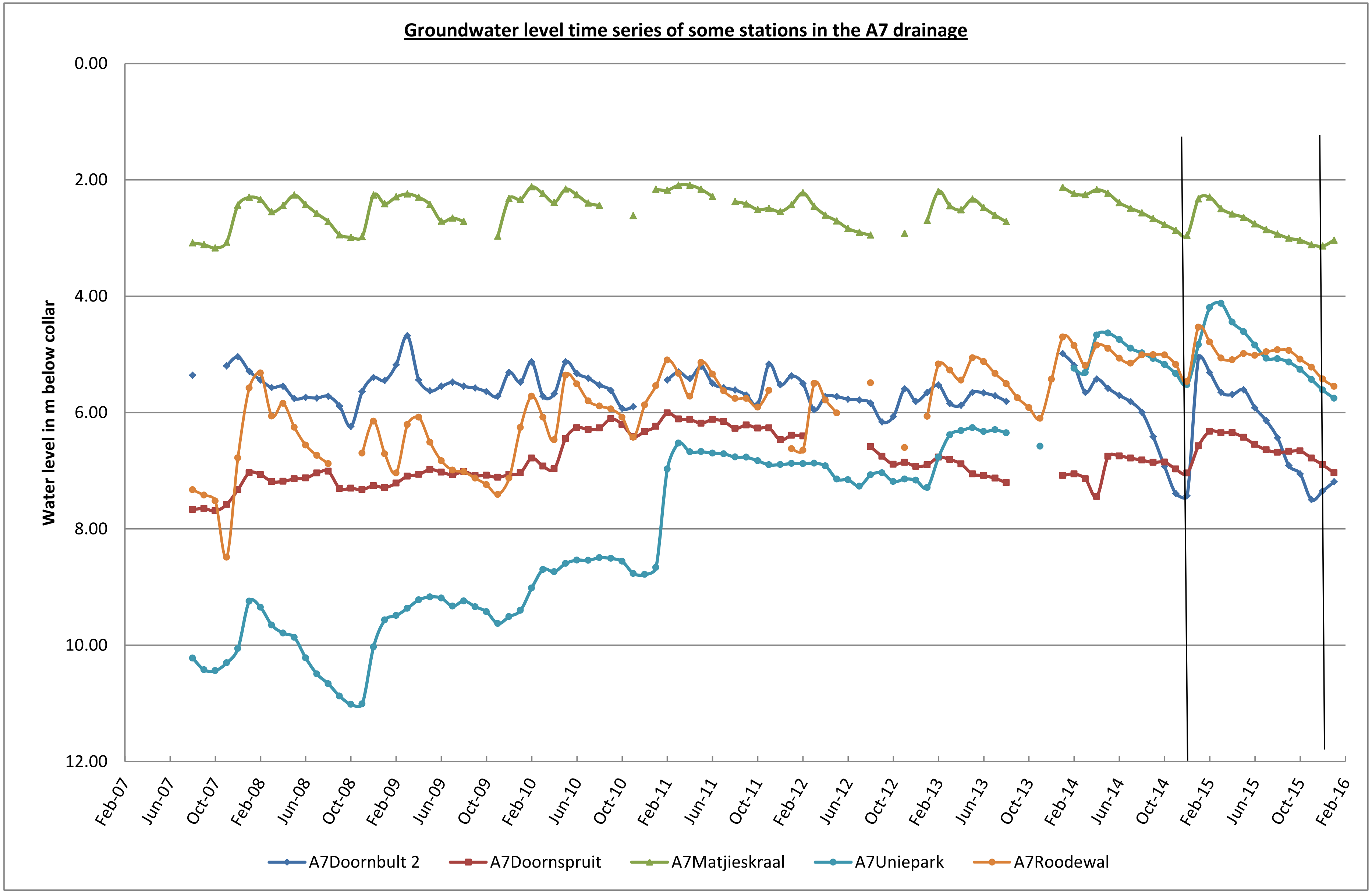
GRAPH 6


Groundwater level time series and rainfall at some stations in the northern part of the A6 drainage
Water level in m
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
400
350
300
250
200
150
100
50
0
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
Rainfall Venetia mine
Rainfall Tolwe
Rainfall Platjan
A6Bridgewater
A6Cantebury
A6Sekhung

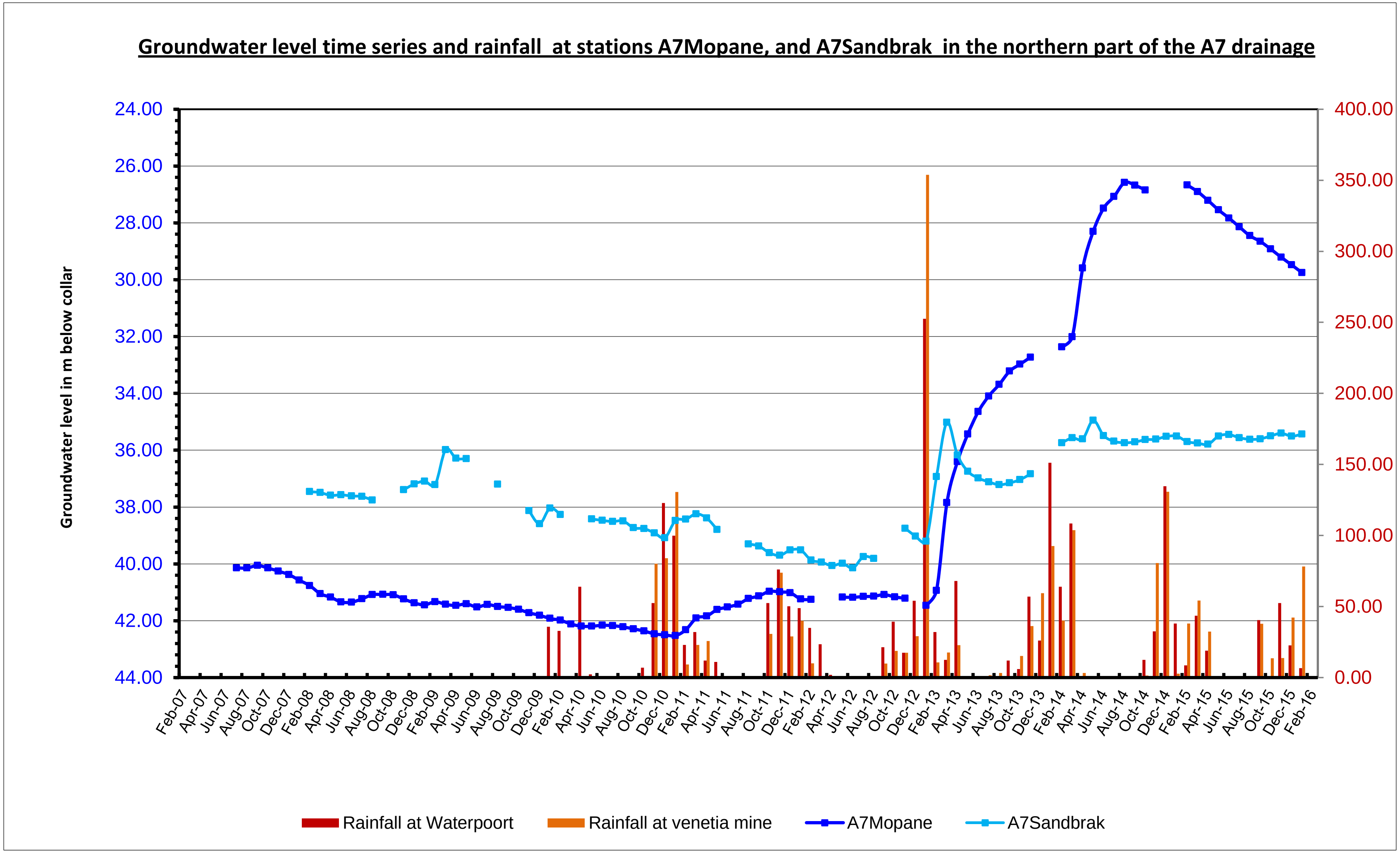
GRAPH 7


Comparison of groundwater levels in the A7 drainage; 31 December 2014 and 31 December 2015
Axis Title
0.00
10.00
20.00
30.00
40.00
50.00
60.00
A7Mara
A7Doornkraal
A7Roodewal
A7Boomzien
A7Tweefontein
A7Sterkloop Pump
A7Waterland
A7Sterkloop farm
A7Westenburg
A7Doornkraal 2
A7Ledig
A7Antonvilla
A7Zandrivierspoort 2
A7Greefswald
A7Matjieskraal
A7Matjieskraal2
A7Sebayeng
A7Beaule
A7Doornpruit
A7Uniepark
A7Seshego
A7Eistleben
A7Geyser
A7Kalkgat
A7Pelgrimshoop 2
A7Legkraal
A7Mopane
A7Doornbult 2
A7Boordepot
A7Sekiding 2
A7Klein Bolayi
A7Venetia Road
A7Sandbrak
A7Waterpoort
A7Zandrivierspoort 3
A7Papkuil
A7Palmietgat
A7Ga-Phashsa
A7Bandolierkop
A7Ga-Matamanyane
A7Dikgomong
A7Langjan
A7Makibelo
01 January 2015
01 January 2016

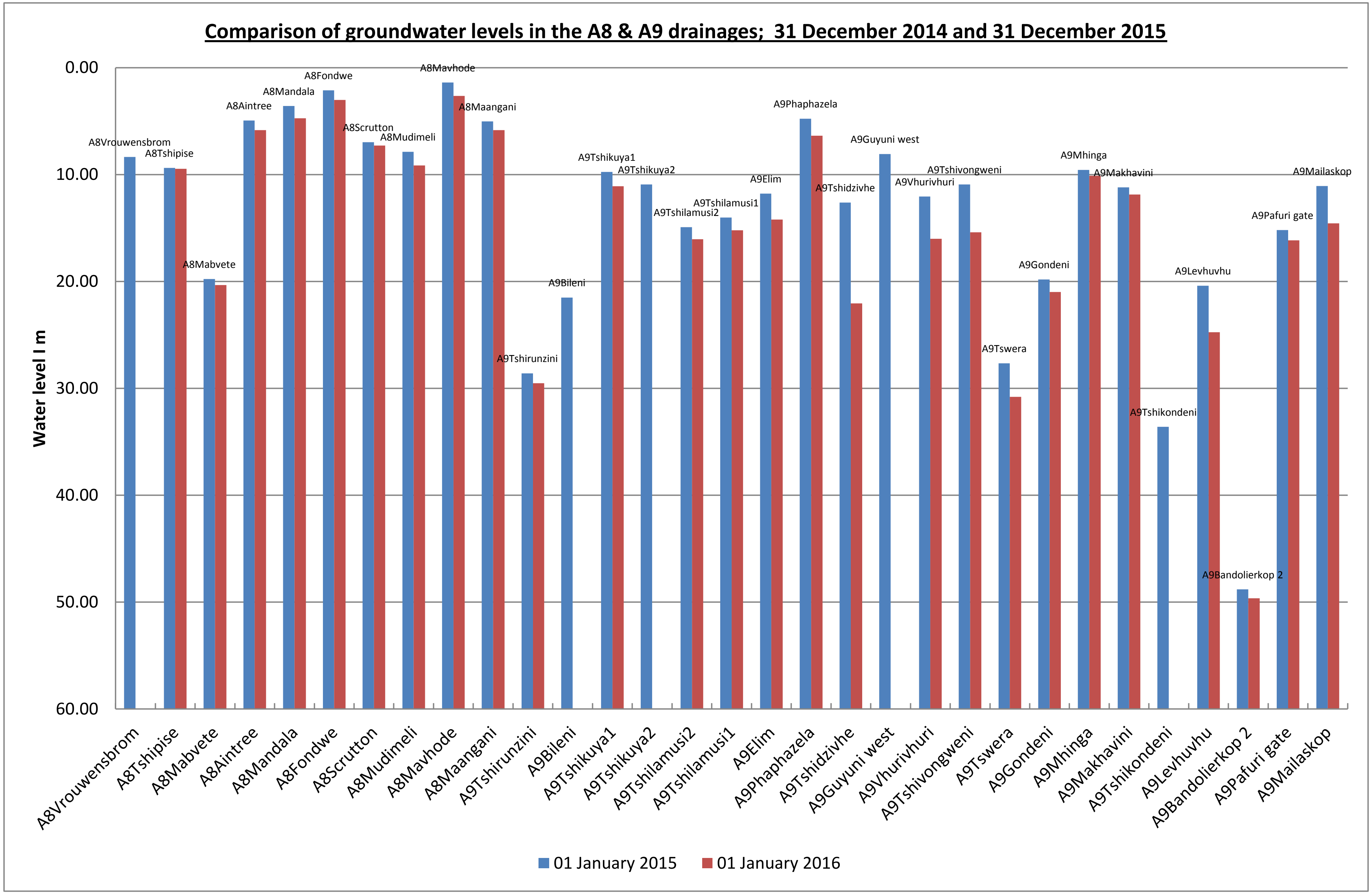
GRAPH 8


Groundwater level time series of some stations in the A7 drainage
Water level in m below collar
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
A7Doornbult 2
A7Doornspruit
A7Matjieskraal
A7Uniepark
A7Roodewal

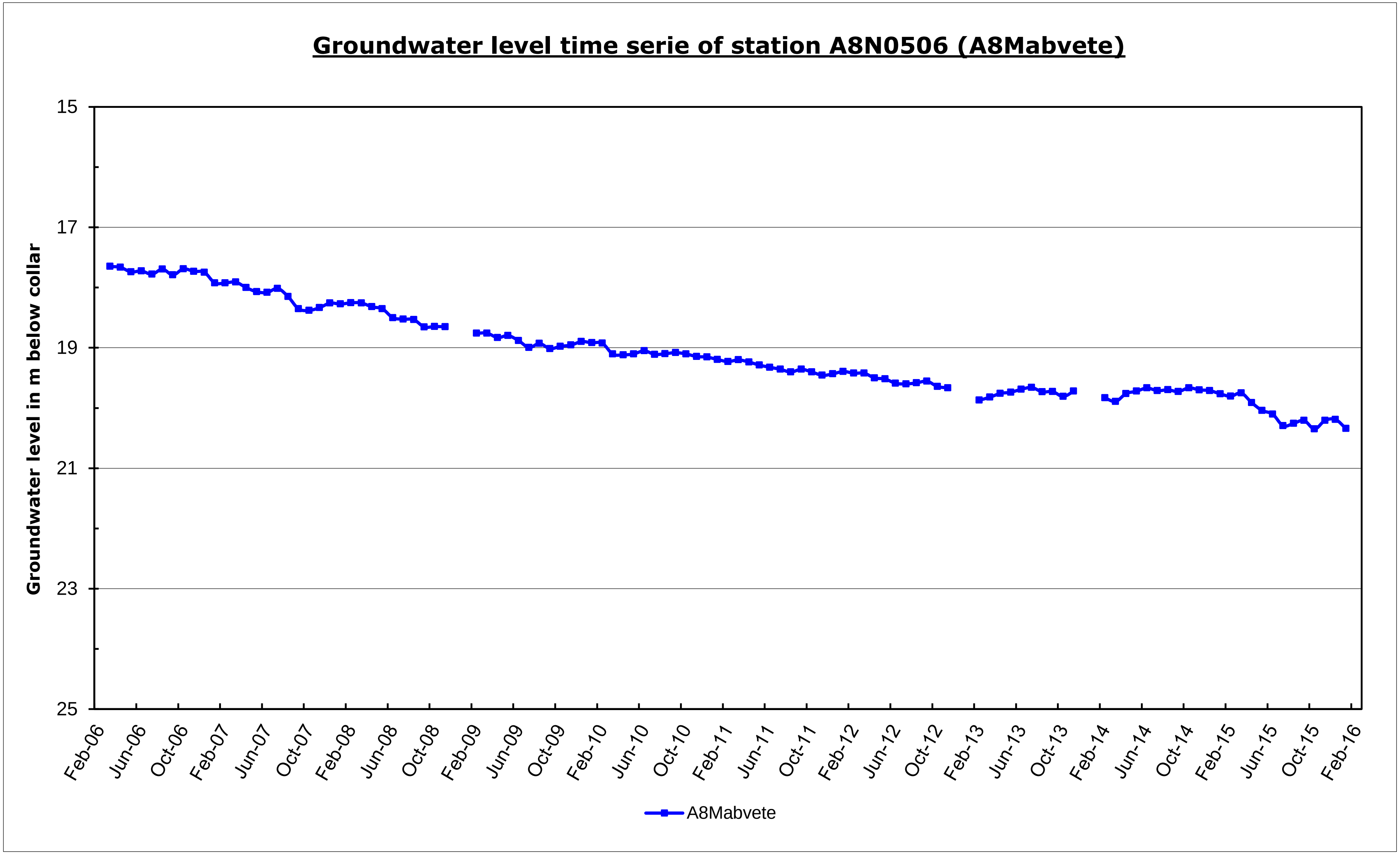
GRAPH 9


Groundwater level time series and rainfall at stations A7Mopane, and A7Sandbrak in the northern part of the A7 drainage
Groundwater level in m below collar
24.00
26.00
28.00
30.00
32.00
34.00
36.00
38.00
40.00
42.00
44.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Feb-07 Apr-07 Jun-07 Aug-07 Oct-07 Dec-07 Feb-08 Apr-08 Jun-08 Aug-08 Oct-08 Dec-08 Feb-09 Apr-09 Jun-09 Aug-09 Oct-09 Dec-09 Feb-10 Apr-10 Jun-10 Aug-10 Oct-10 Dec-10 Feb-11 Apr-11 Jun-11 Aug-11 Oct-11 Dec-11 Feb-12 Apr-12 Jun-12 Aug-12 Oct-12 Dec-12 Feb-13 Apr-13 Jun-13 Aug-13 Oct-13 Dec-13 Feb-14 Apr-14 Jun-14 Aug-14 Oct-14 Dec-14 Feb-15 Apr-15 Jun-15 Aug-15 Oct-15 Dec-15 Feb-16
Rainfall at Waterpoort
Rainfall at venetia mine
A7Mopane
A7Sandbrak

GRAPH 10

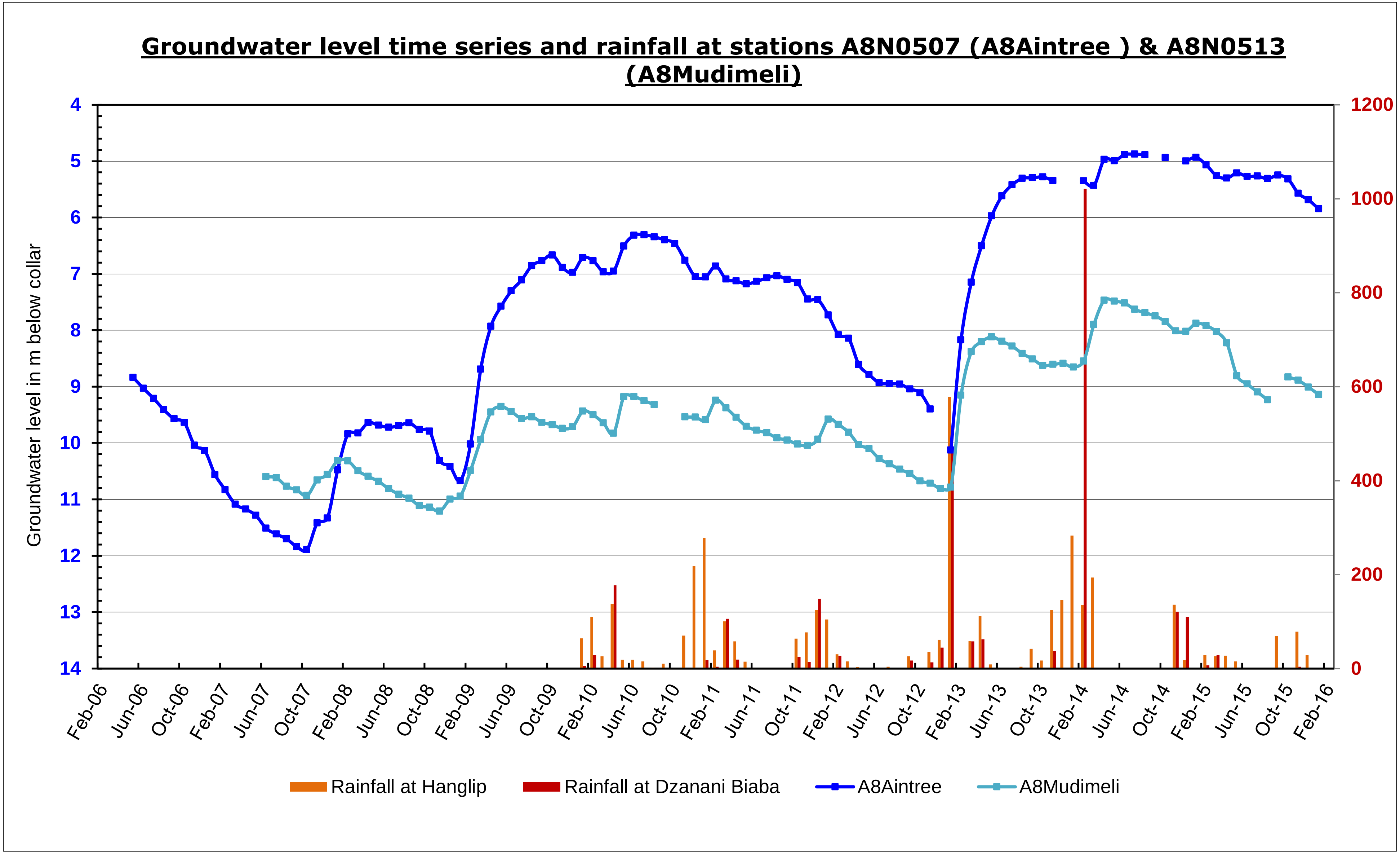

Comparison of groundwater levels in the A8 & A9 drainages; 31 December 2014 and 31 December 2015
Water level I m
0.00
10.00
20.00
30.00
40.00
50.00
60.00
A8Vrouwensbrom
A8Tshipise
A8Mabvete
A8Aintree
A8Mandala
A8Fondwe
A8Scrutton
A8Mudimeli
A8Mavhode
A8Maangani
A9Tshirunzini
A9Bileni
A9Tshikuya1
A9Tshikuya2
A9Tshilamusi2
A9Tshilamusi1
A9Elim
A9Phaphazela
A9Tshidzivhe
A9Guyuni west
A9Vhurivhuri
A9Tshivongweni
A9Tswera
A9Gondeni
A9Mhinga
A9Makhavini
A9Tshikondeni
A9Levhuvhu
A9Bandolierkop 2
A9Pafuri gate
A9Mailaskop
01 January 2015
01 January 2016

GRAPH 11



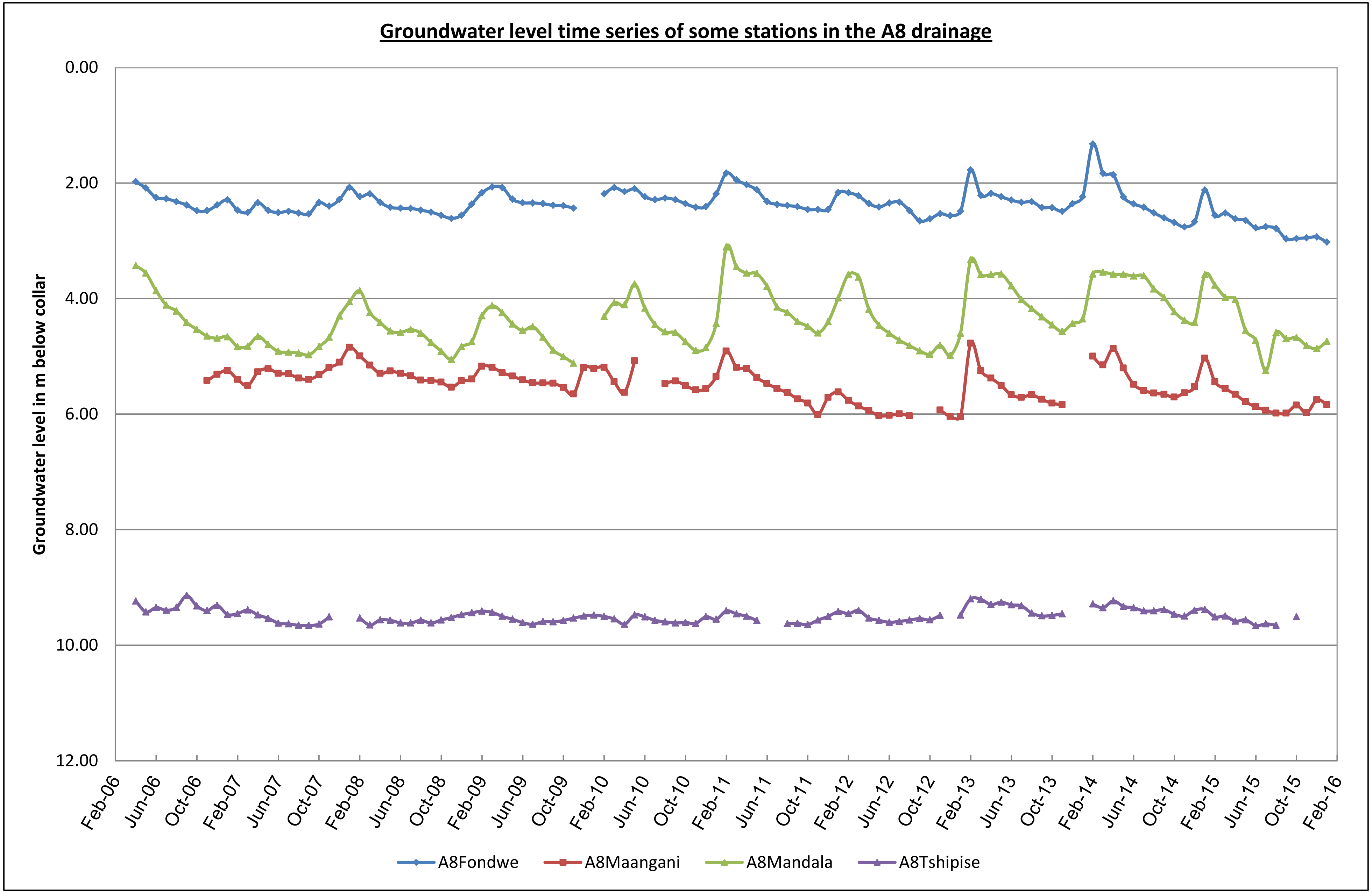
Groundwater level time serie of station A8N0506 (A8Mabvete)
Groundwater level in m below collar
15
17
19
21
23
25
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
A8Mabvete

GRAPH 12

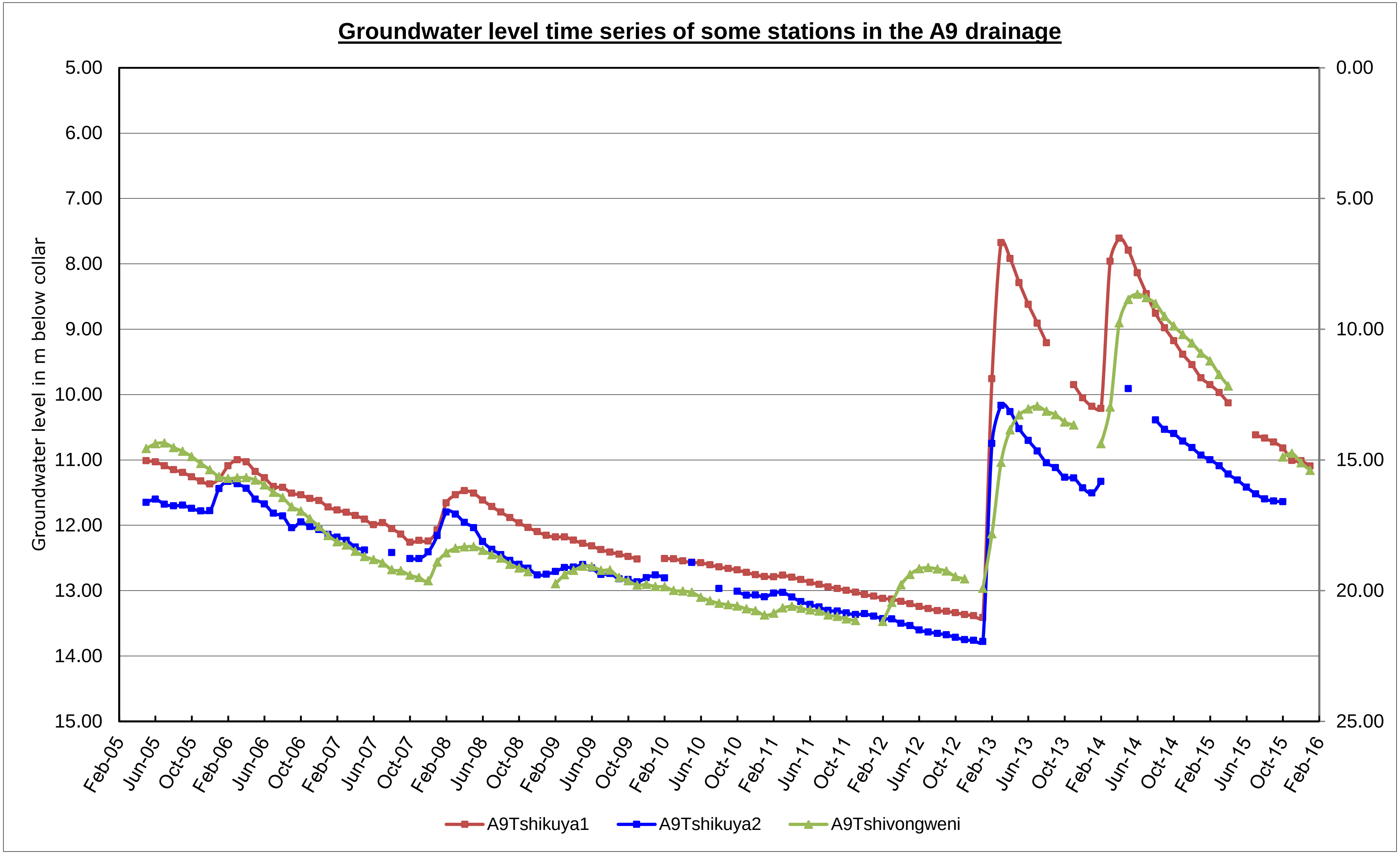


Groundwater level time series and rainfall at stations A8N0507 (A8Aintree) & A8N0513 (A8Mudimeli)
Groundwater level in m below collar
4
5
6
7
8
9
10
11
12
13
14
1200
1000
800
600
400
200
0
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
Rainfall at Hanglip
Rainfall at Dzanani Biaba
A8Aintree
A8Mudimeli

GRAPH 13

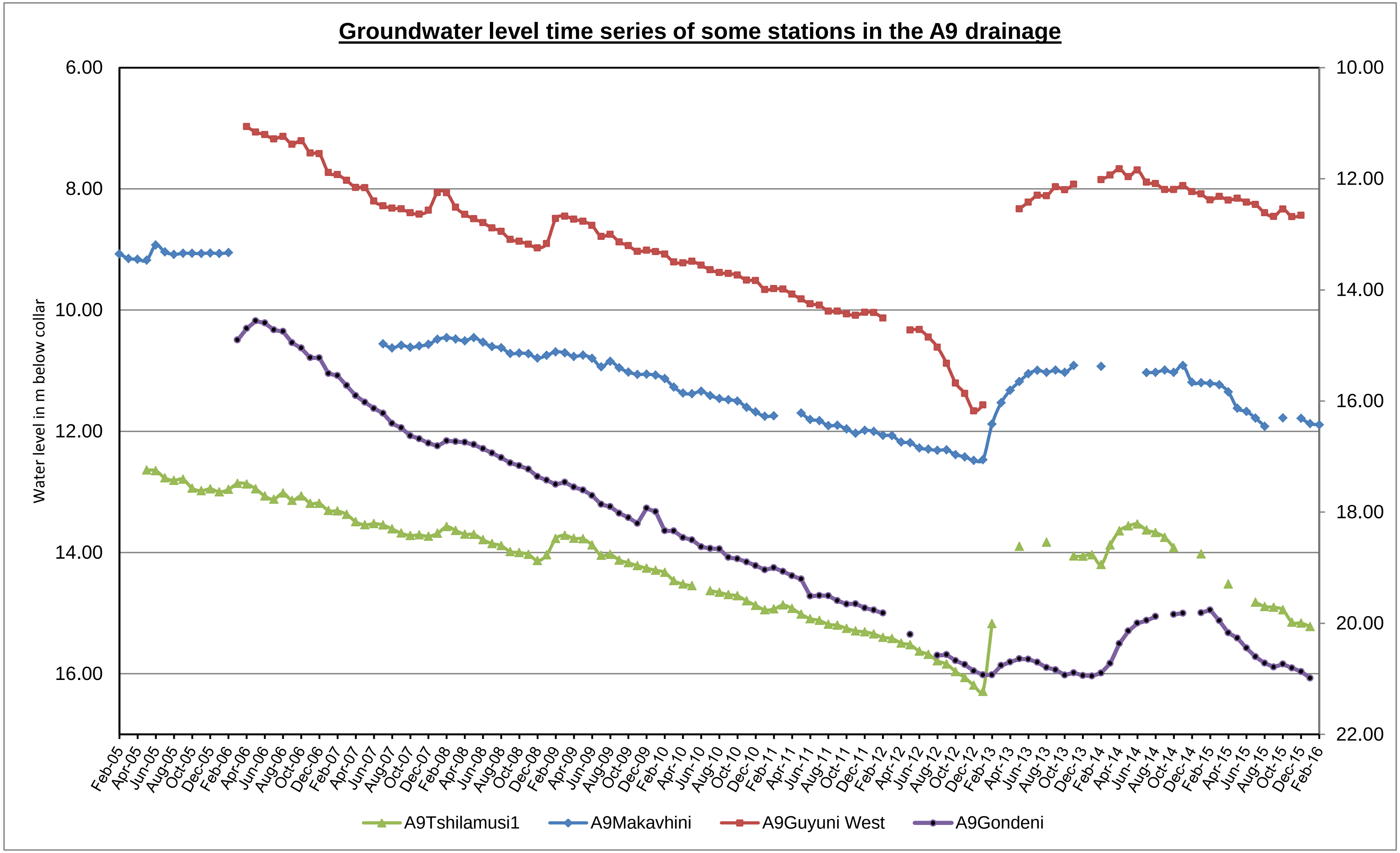

Groundwater level time series of some stations in the A8 drainage
Groundwater level in m below collar
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
A8Fondwe
A8Maangani
A8Mandala
A8Tshipise

GRAPH 14



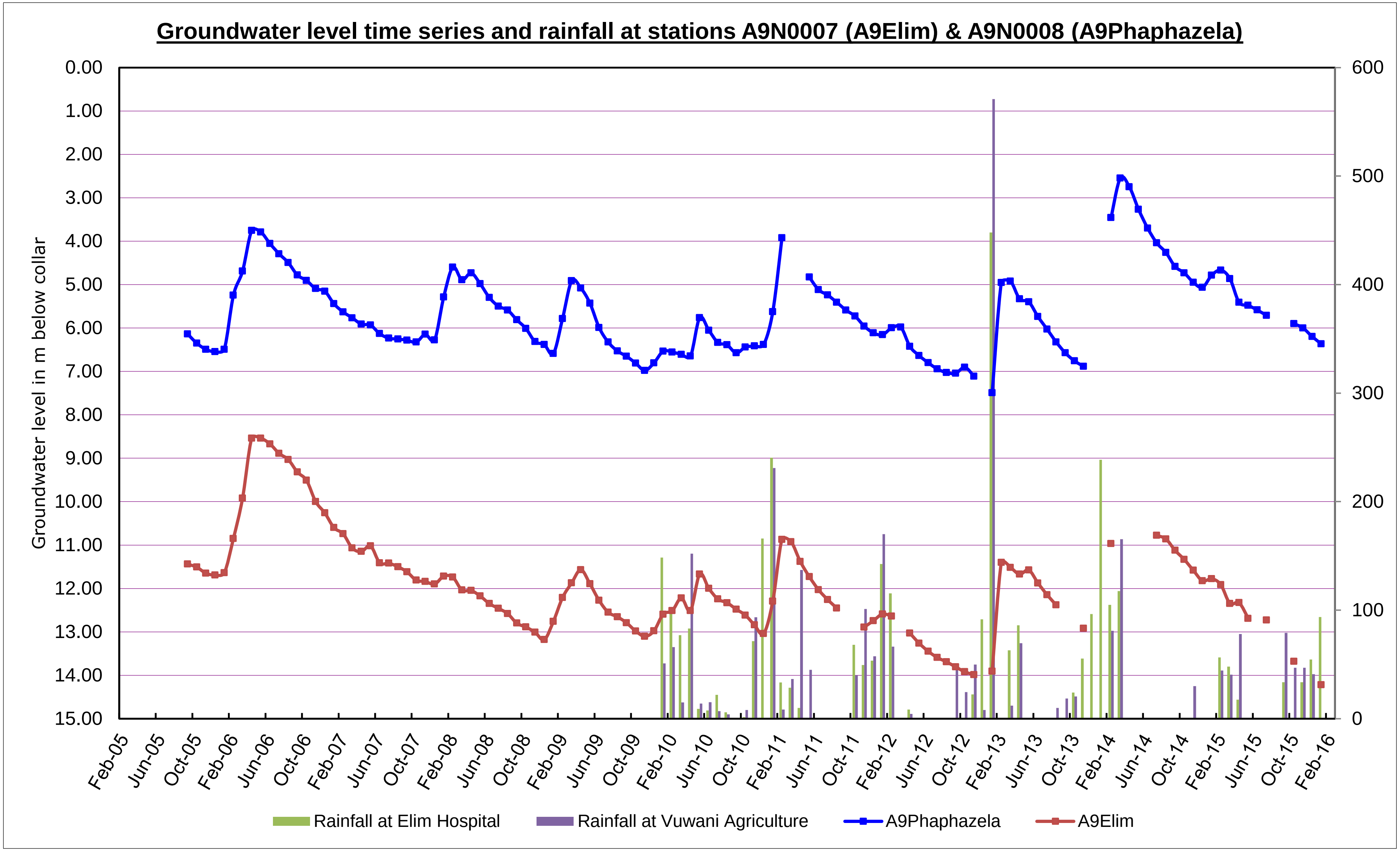
Groundwater level time series of some stations in the A9 drainage
Groundwater level in m below collar
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
0.00
5.00
10.00
15.00
20.00
25.00
Feb-05
Jun-05
Oct-05
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
A9Tshikuya1
A9Tshikuya2
A9Tshivongweni

GRAPH 15



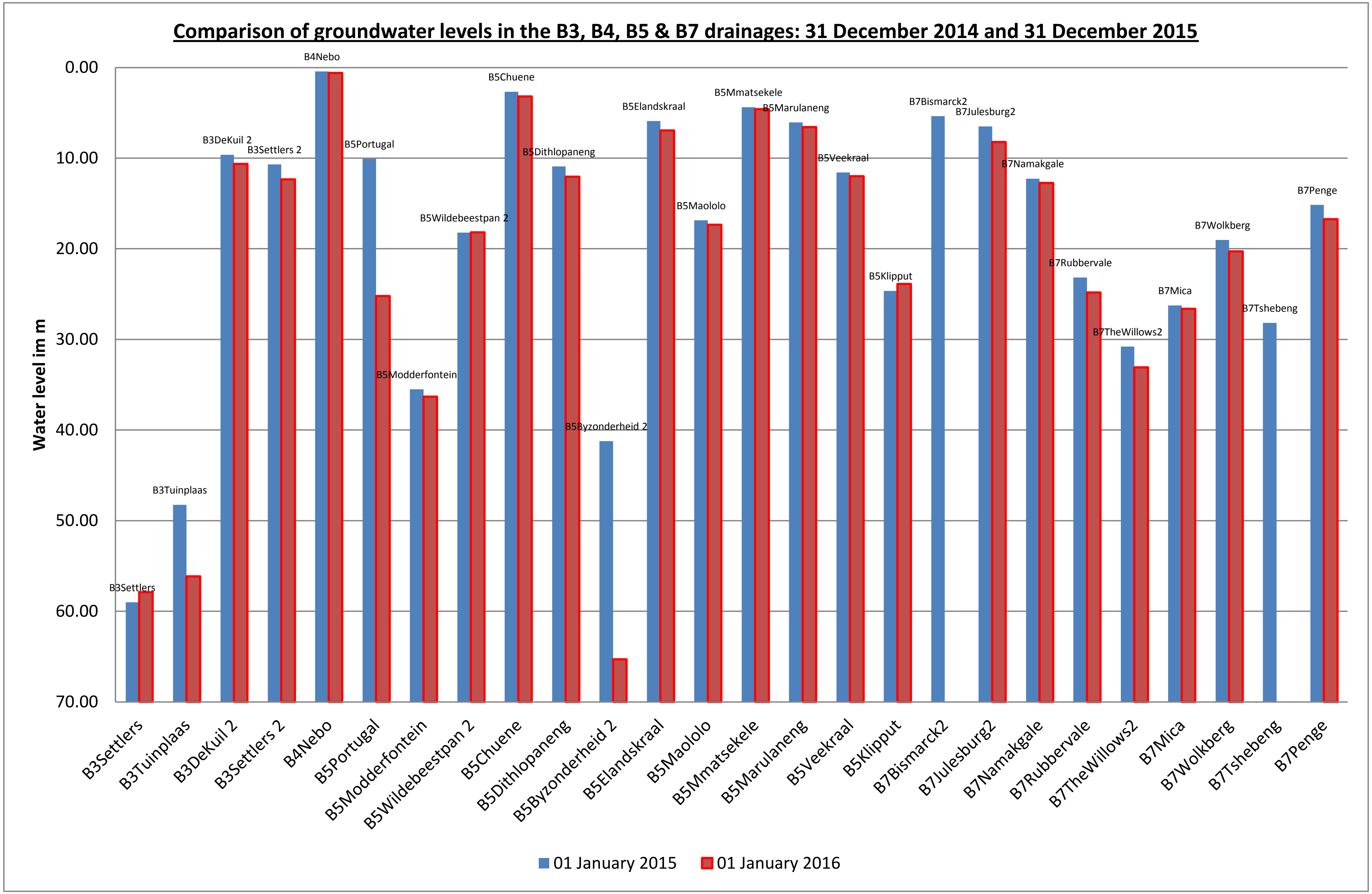
Groundwater level time series of some stations in the A9 drainage
Water level in m below collar
6.00
8.00
10.00
12.00
14.00
16.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
Feb-05
Apr-05
Jun-05
Aug-05
Oct-05
Dec-05
Feb-06
Apr-06
Jun-06
Aug-06
Oct-06
Dec-06
Feb-07
Apr-07
Jun-07
Aug-07
Oct-07
Dec-07
Feb-08
Apr-08
Jun-08
Aug-08
Oct-08
Dec-08
Feb-09
Apr-09
Jun-09
Aug-09
Oct-09
Dec-09
Feb-10
Apr-10
Jun-10
Aug-10
Oct-10
Dec-10
Feb-11
Apr-11
Jun-11
Aug-11
Oct-11
Dec-11
Feb-12
Apr-12
Jun-12
Aug-12
Oct-12
Dec-12
Feb-13
Apr-13
Jun-13
Aug-13
Oct-13
Dec-13
Feb-14
Apr-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
A9Tshilamusi1
A9Makavhini
A9Guyuni West
A9Gondeni

GRAPH 16

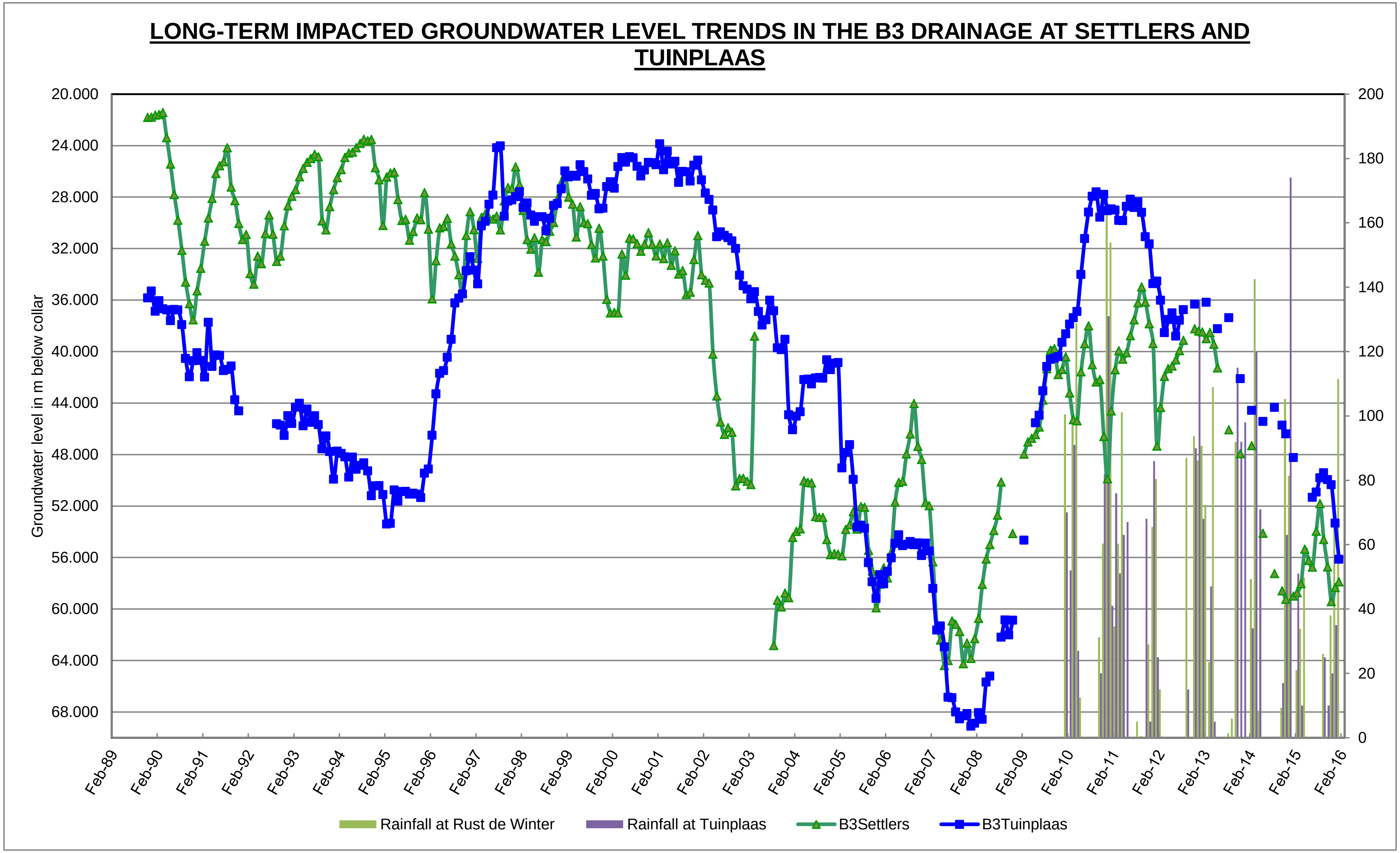


Groundwater level time series and rainfall at stations A9N0007 (A9Elim) & A9N0008 (A9Phaphazela)
Groundwater level in m below collar
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
600
500
400
300
200
100
0
Feb-05
Jun-05
Oct-05
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
Rainfall at Elim Hospital
Rainfall at Vuwani Agriculture
A9Phaphazela
A9Elim

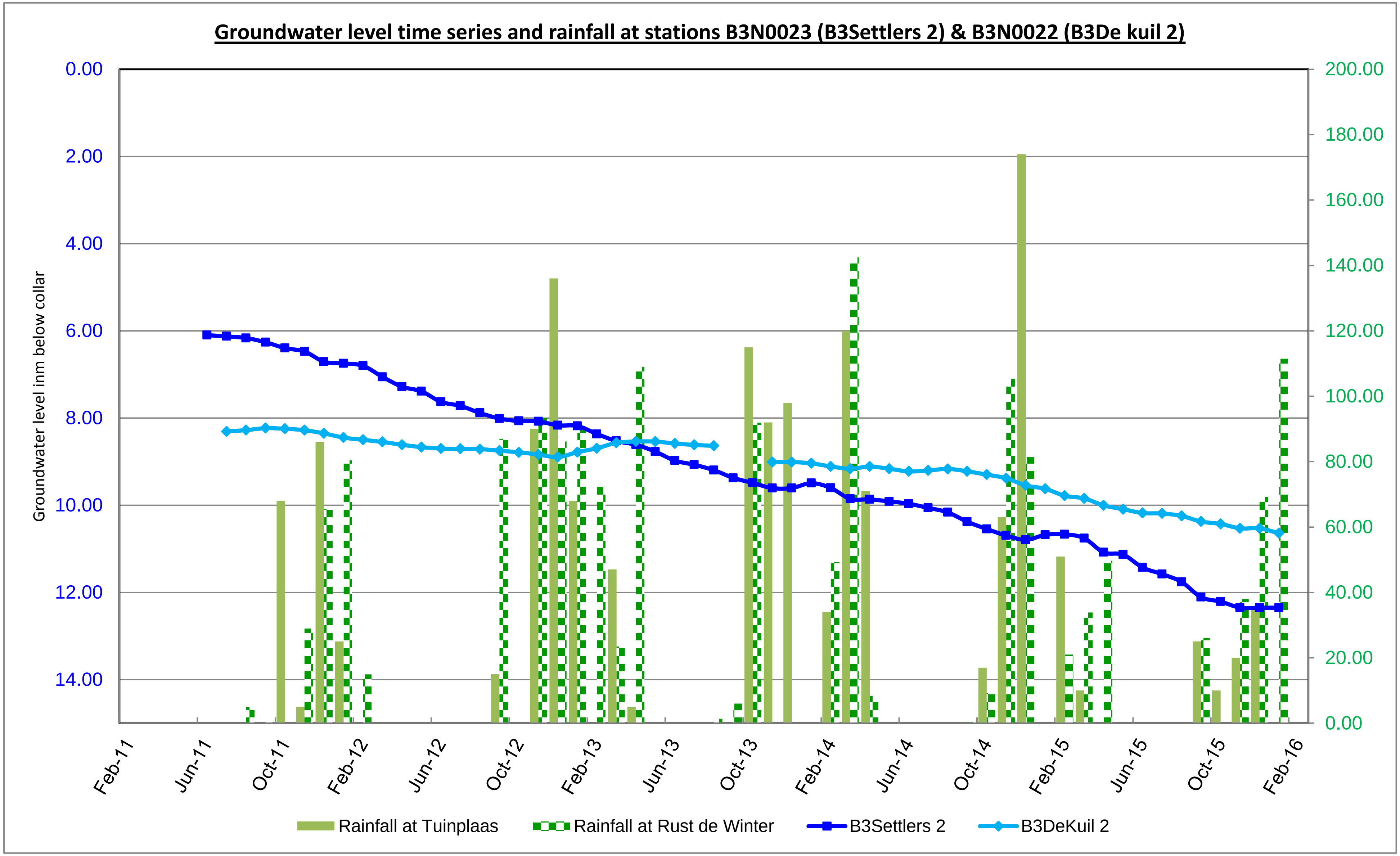
GRAPH 17


Comparison of groundwater levels in the B3, B4, B5 & B7 drainages: 31 December 2014 and 31 December 2015
Water level im m
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
B3Settlers
B3Tuinplaas
B3DeKuil 2
B3Settlers 2
B4Nebo
B5Portugal
B5Modderfontein
B5Wildebeestpan 2
B5Chuene
B5Dithlopaneng
B5Byzonderheid 2
B5Elandskraal
B5Maololo
B5Mmatsekele
B5Marulaneng
B5Veekraal
B5Klipput
B7Bismarck2
B7Julesburg2
B7Namakgale
B7Rubbervale
B7TheWillows2
B7Mica
B7Wolkberg
B7Tshebeng
B7Penge
01 January 2015
01 January 2016

GRAPH 18

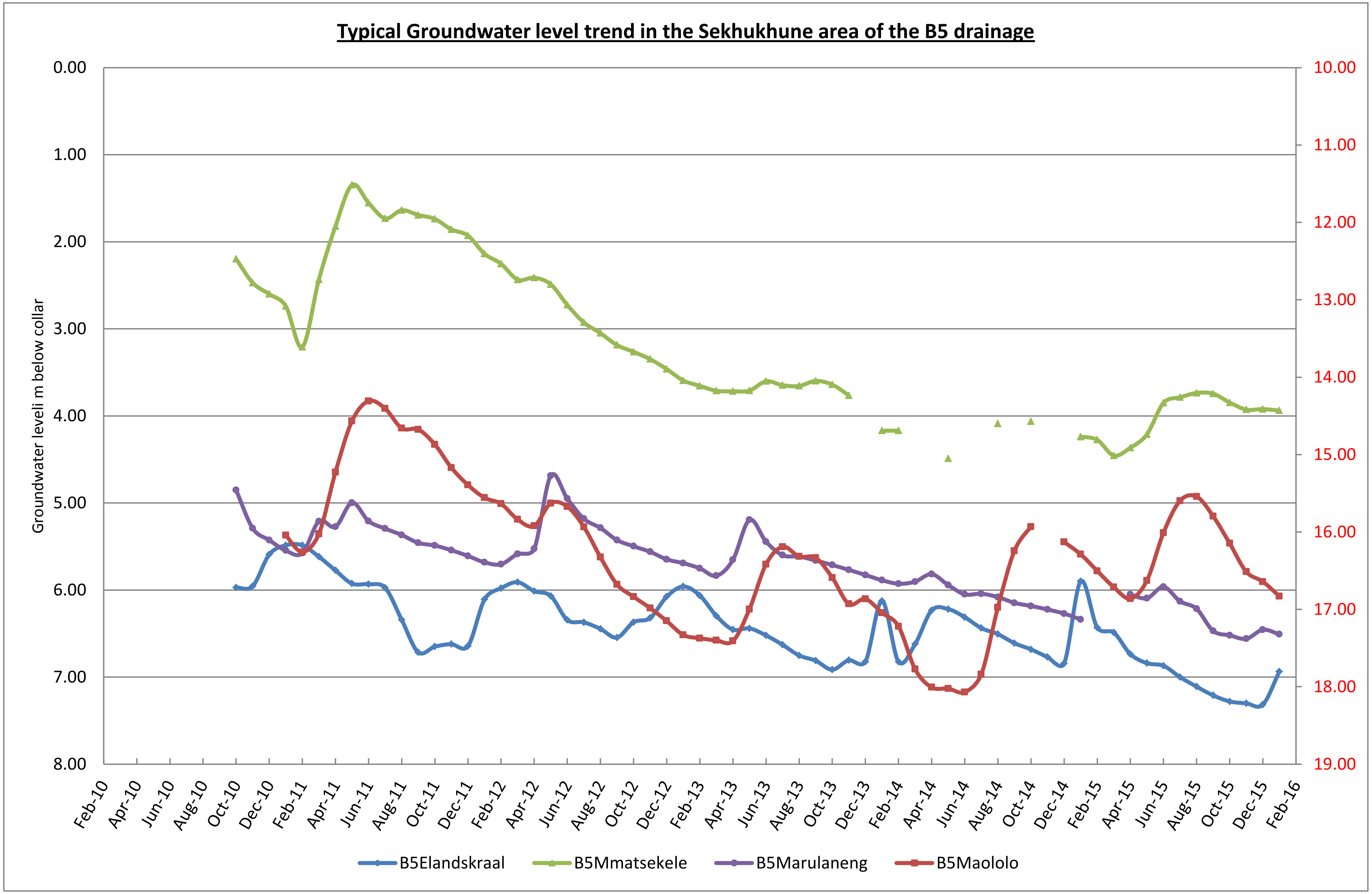

LONG-TERM IMPACTED GROUNDWATER LEVEL TRENDS IN THE B3 DRAINAGE AT SETTLERS AND TUINPLAAS
Groundwater level in m below collar
20.000
24.000
28.000
32.000
36.000
40.000
44.000
48.000
52.000
56.000
60.000
64.000
68.000
200
180
160
140
120
100
80
60
40
20
0
Feb-89
Feb-90
Feb-91
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
Rainfall at Rust de Winter
Rainfall at Tuinplaas
B3Settlers
B3Tuinplaas

GRAPH 19



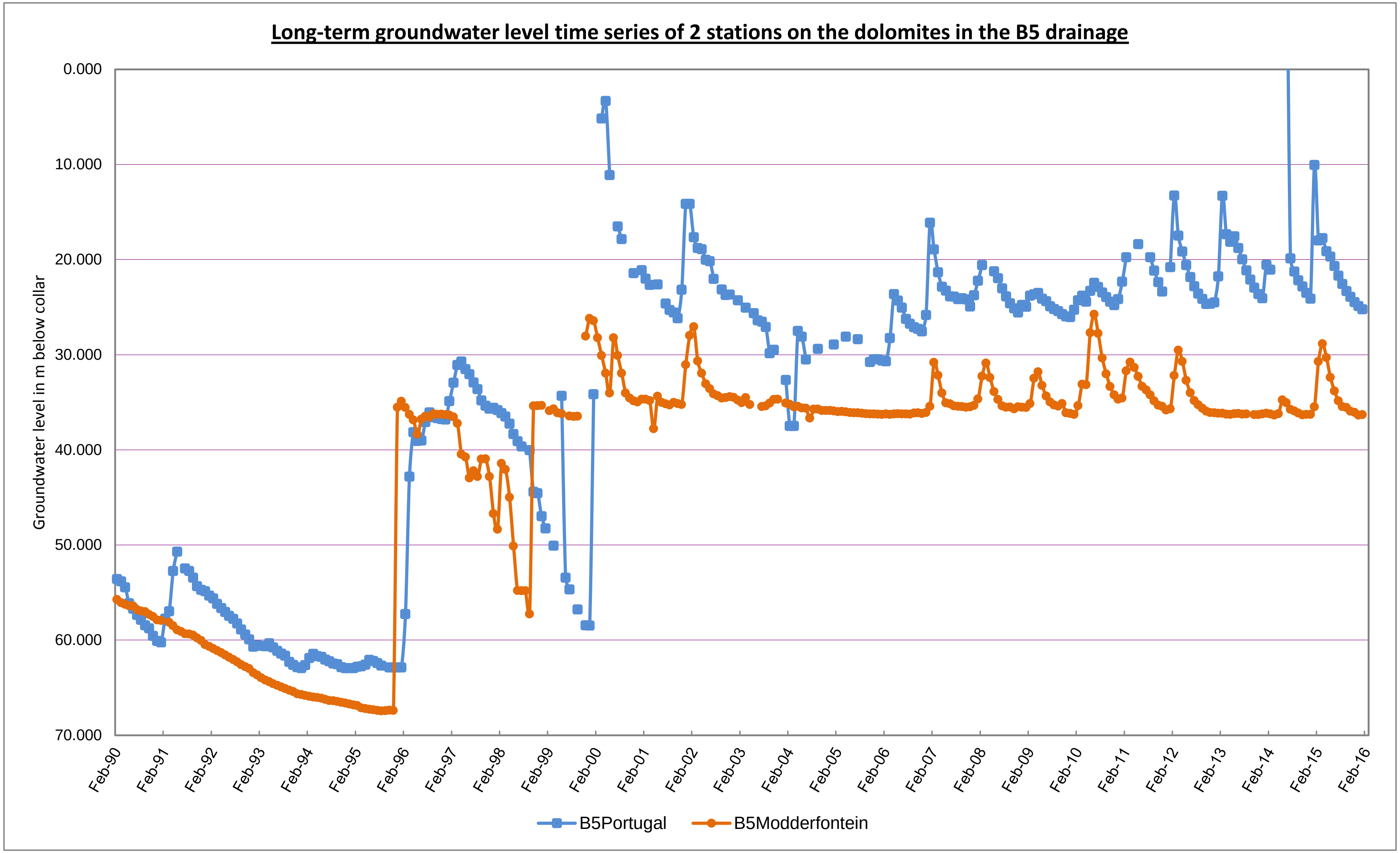
Groundwater level time series and rainfall at stations B3N0023 (B3Settlers 2) & B3N0022 (B3De kuil 2)
Groundwater level inm below collar
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
Rainfall at Tuinplaas
Rainfall at Rust de Winter
B3Settlers 2
B3DeKuil 2

GRAPH 20

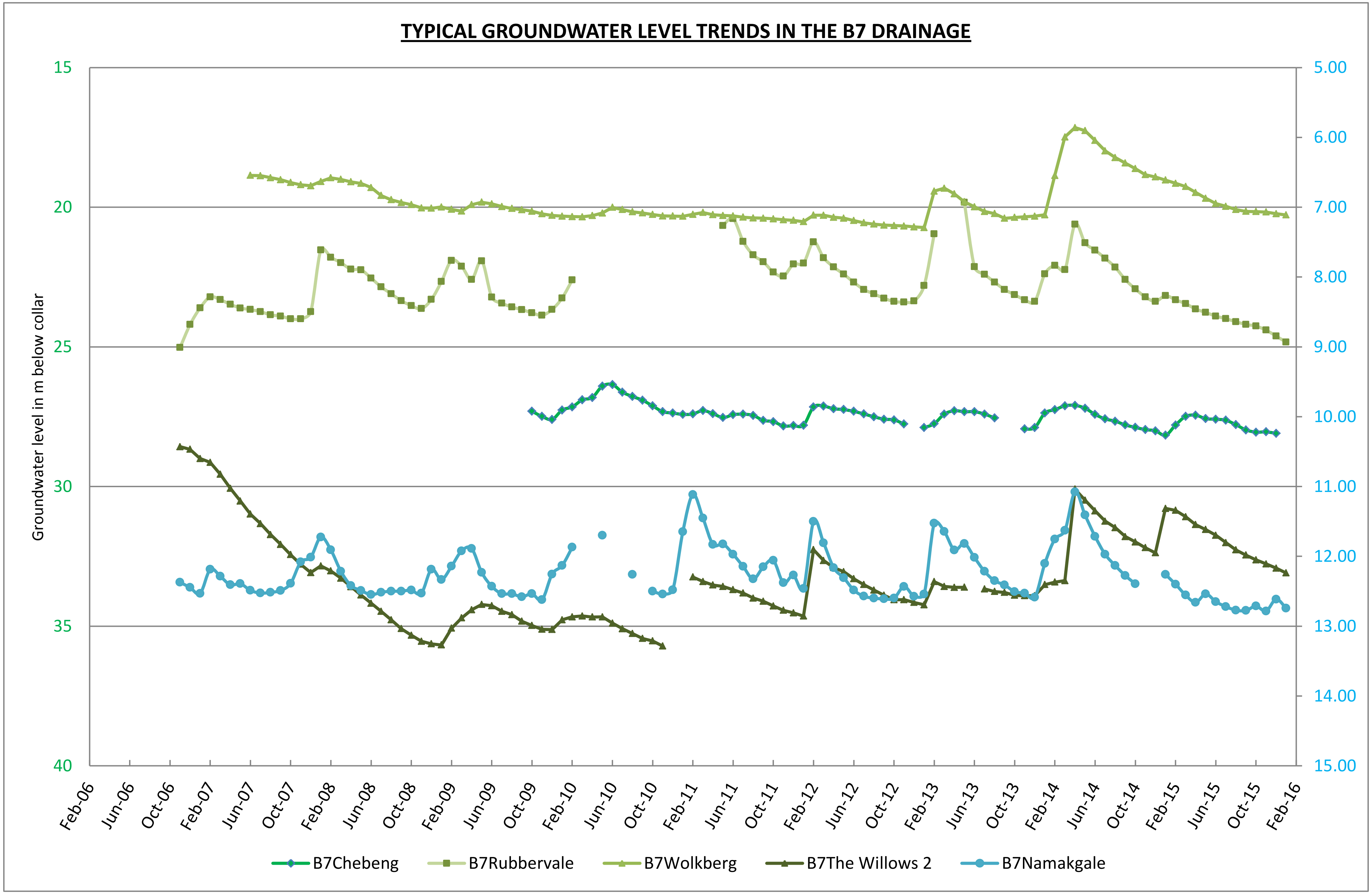


Typical Groundwater level trend in the Sekhukhune area of the B5 drainage
Groundwater leveli m below collar
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
Feb-10
Apr-10
Jun-10
Aug-10
Oct-10
Dec-10
Feb-11
Apr-11
Jun-11
Aug-11
Oct-11
Dec-11
Feb-12
Apr-12
Jun-12
Aug-12
Oct-12
Dec-12
Feb-13
Apr-13
Jun-13
Aug-13
Oct-13
Dec-13
Feb-14
Apr-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
B5Elandskraal
B5Mmatsekele
B5Marulaneng
B5Maololo

GRAPH 21

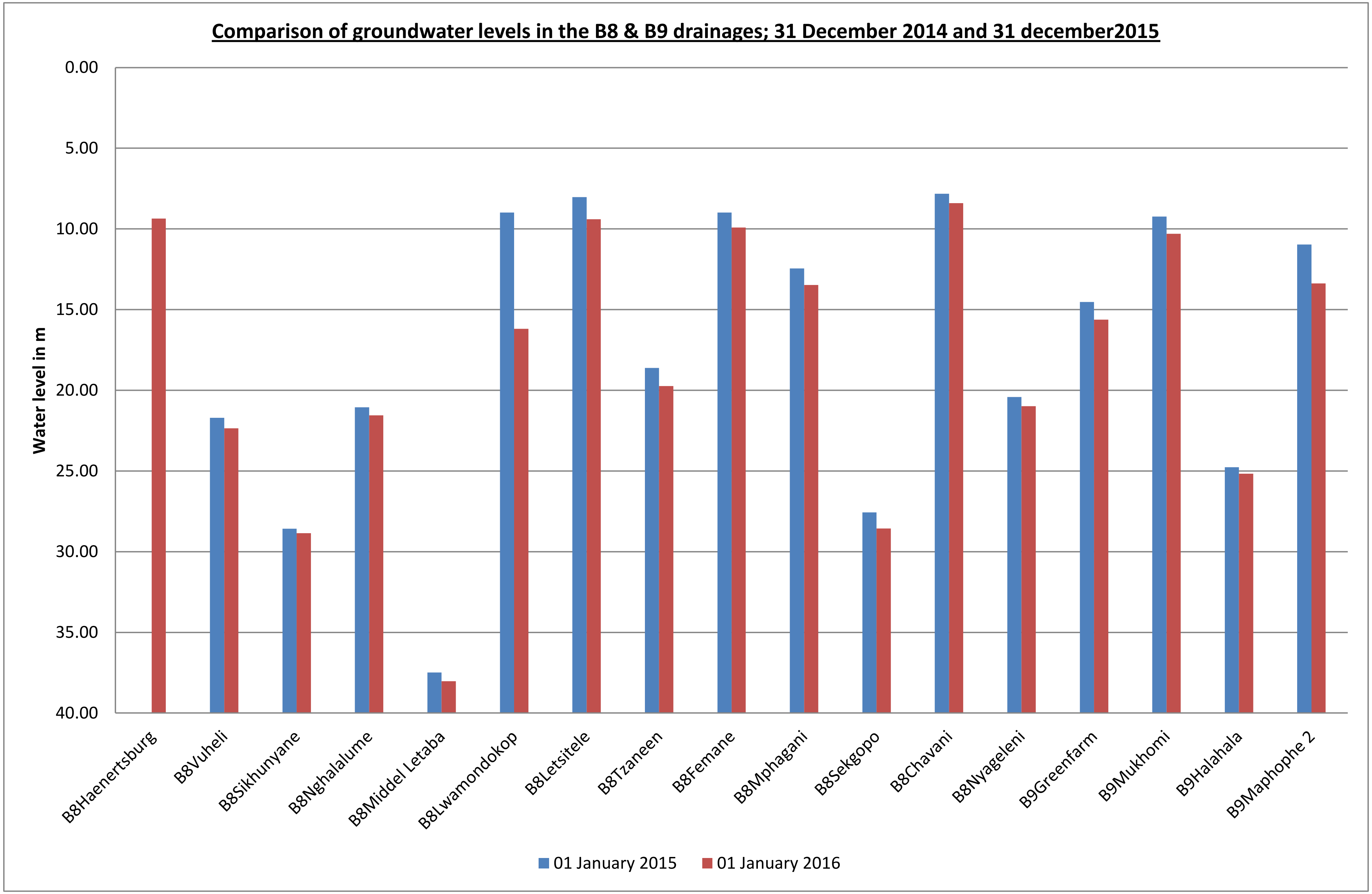

Long-term groundwater level time series of 2 stations on the dolomites in the B5 drainage
Groundwater level in m below collar
0.000
10.000
20.000
30.000
40.000
50.000
60.000
70.000
Feb-90
Feb-91
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
B5Portugal
B5Modderfontein

GRAPH 22

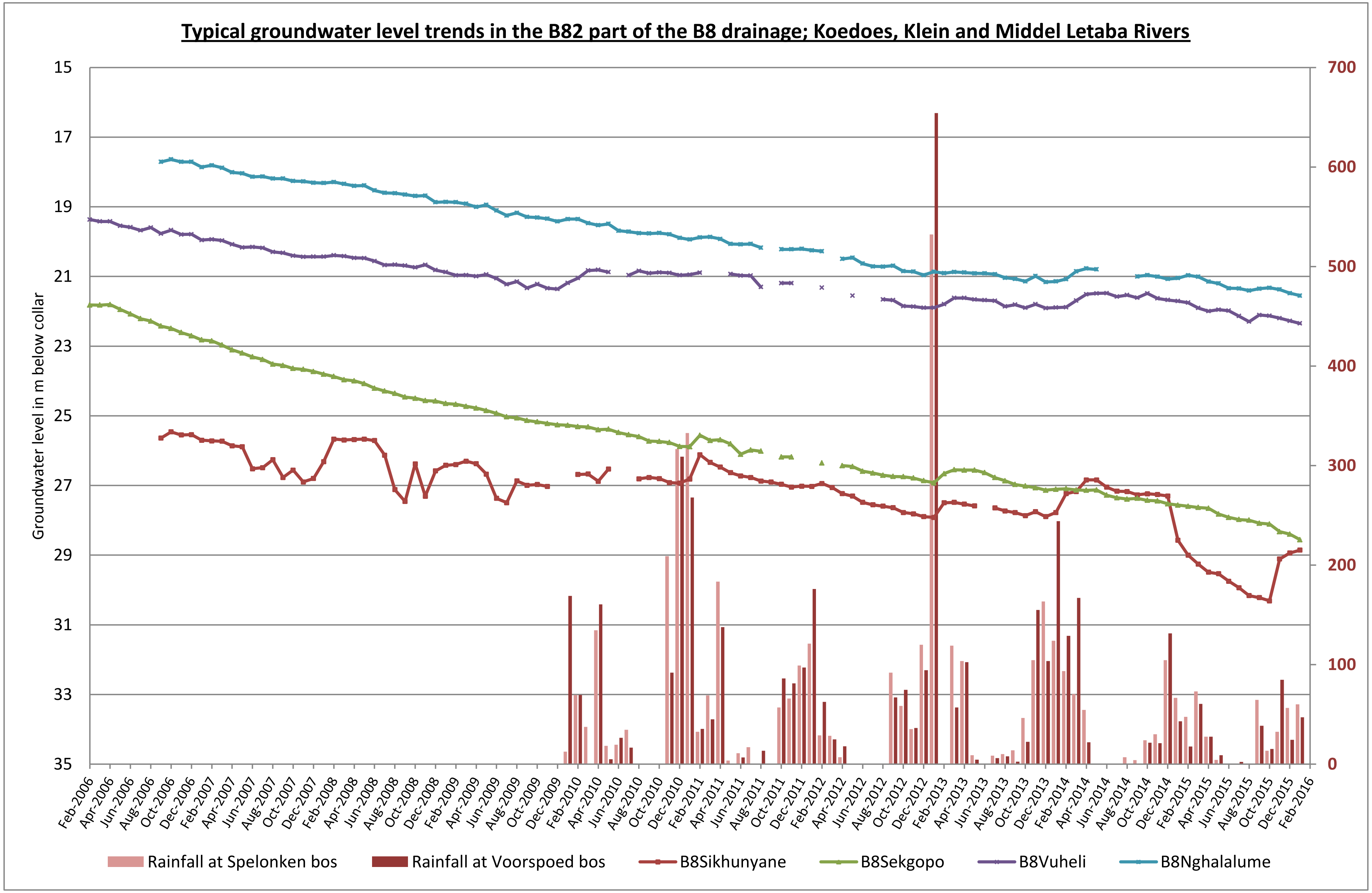


TYPICAL GROUNDWATER LEVEL TRENDS IN THE B7 DRAINAGE
Groundwater level in m below collar
15
20
25
30
35
40
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
B7Chebeng
B7Rubbervale
B7Wolkberg
B7The Willows 2
B7Namakgale

GRAPH 23

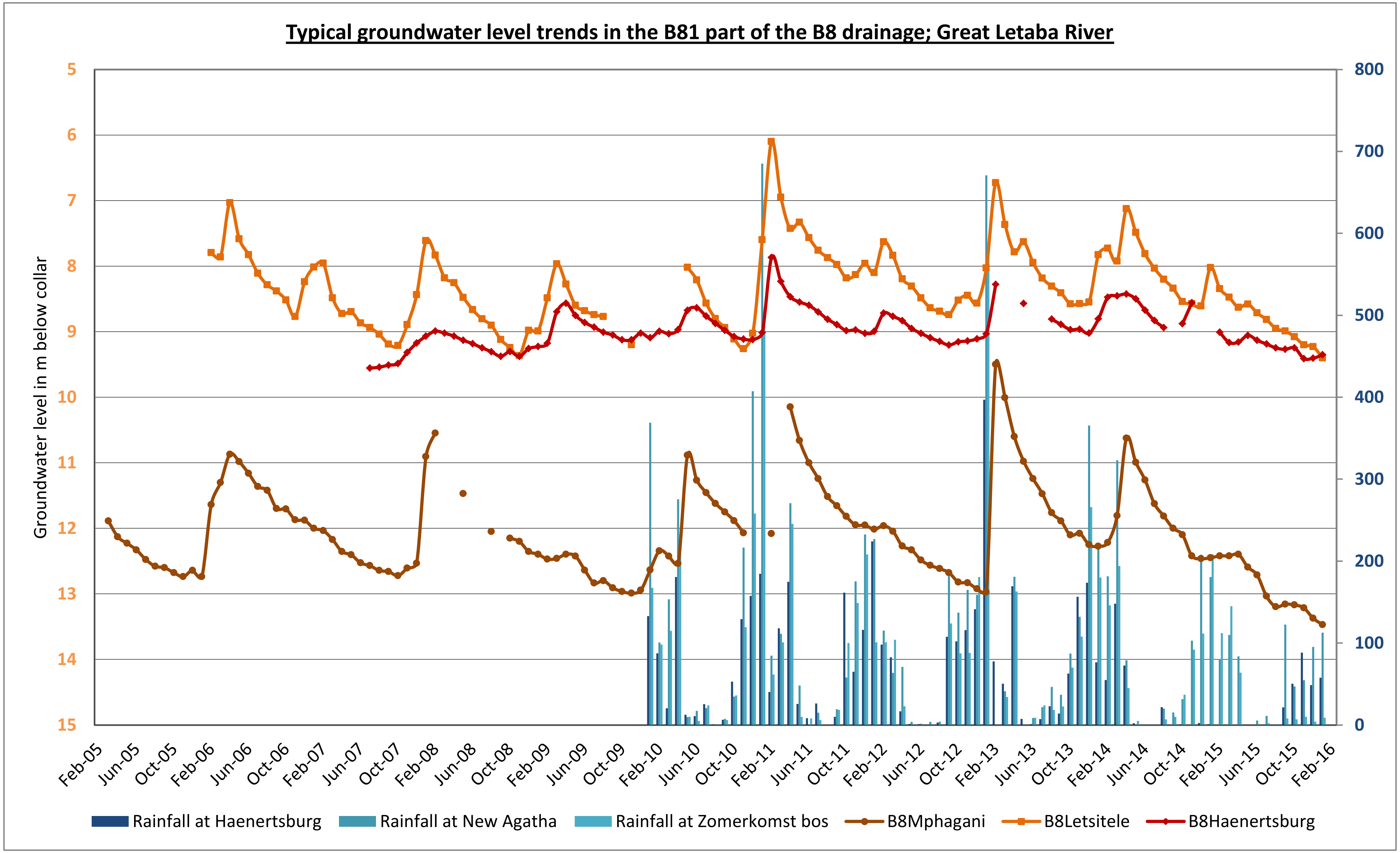

Comparison of groundwater levels in the B8 & B9 drainages; 31 December 2014 and 31 december2015
Water level in m
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
B8Haenertsburg
B8Vuheli
B8Sikhunyane
B8Nghalalume
B8Middel Letaba
B8Lwamondokop
B8Letsitele
B8Tzaneen
B8Femane
B8Mphagani
B8Sekgopo
B8Chavani
B8Nyageleni
B9Greenfarm
B9Mukhomi
B9Halahala
B9Maphophe 2
01 January 2015
01 January 2016

GRAPH 24



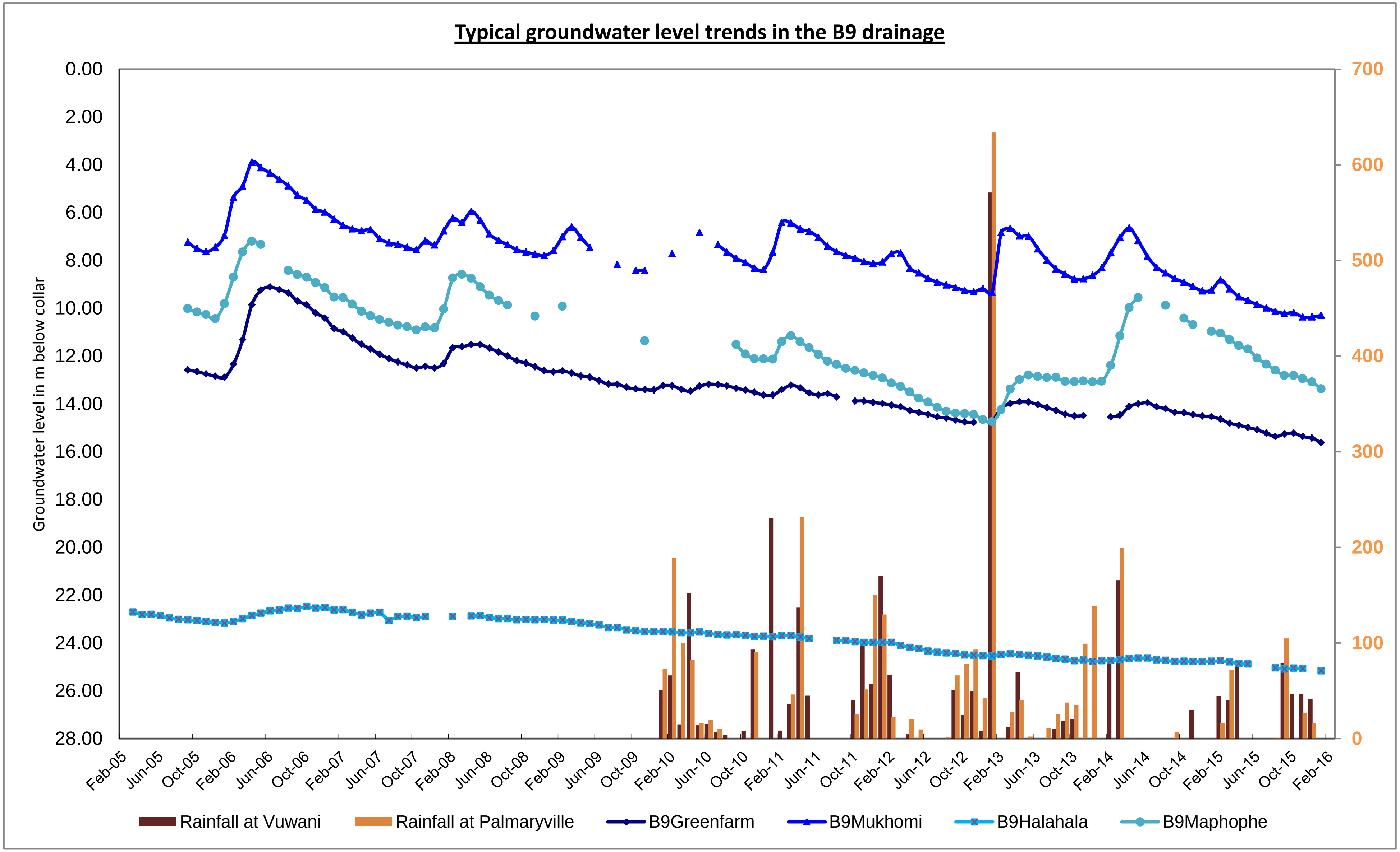
Typical groundwater level trends in the B82 part of the B8 drainage; Koedoes, Klein and Middel Letaba Rivers
Groundwater level in m below collar
15
17
19
21
23
25
27
29
31
33
35
700
600
500
400
300
200
100
0
Feb-2006
Feb-2016
Rainfall at Spelonken bos
Rainfall at Voorspoed bos
B8Sikhunyane
B8Sekgopo
B8Vuheli
B8Nghalalume

GRAPH 25

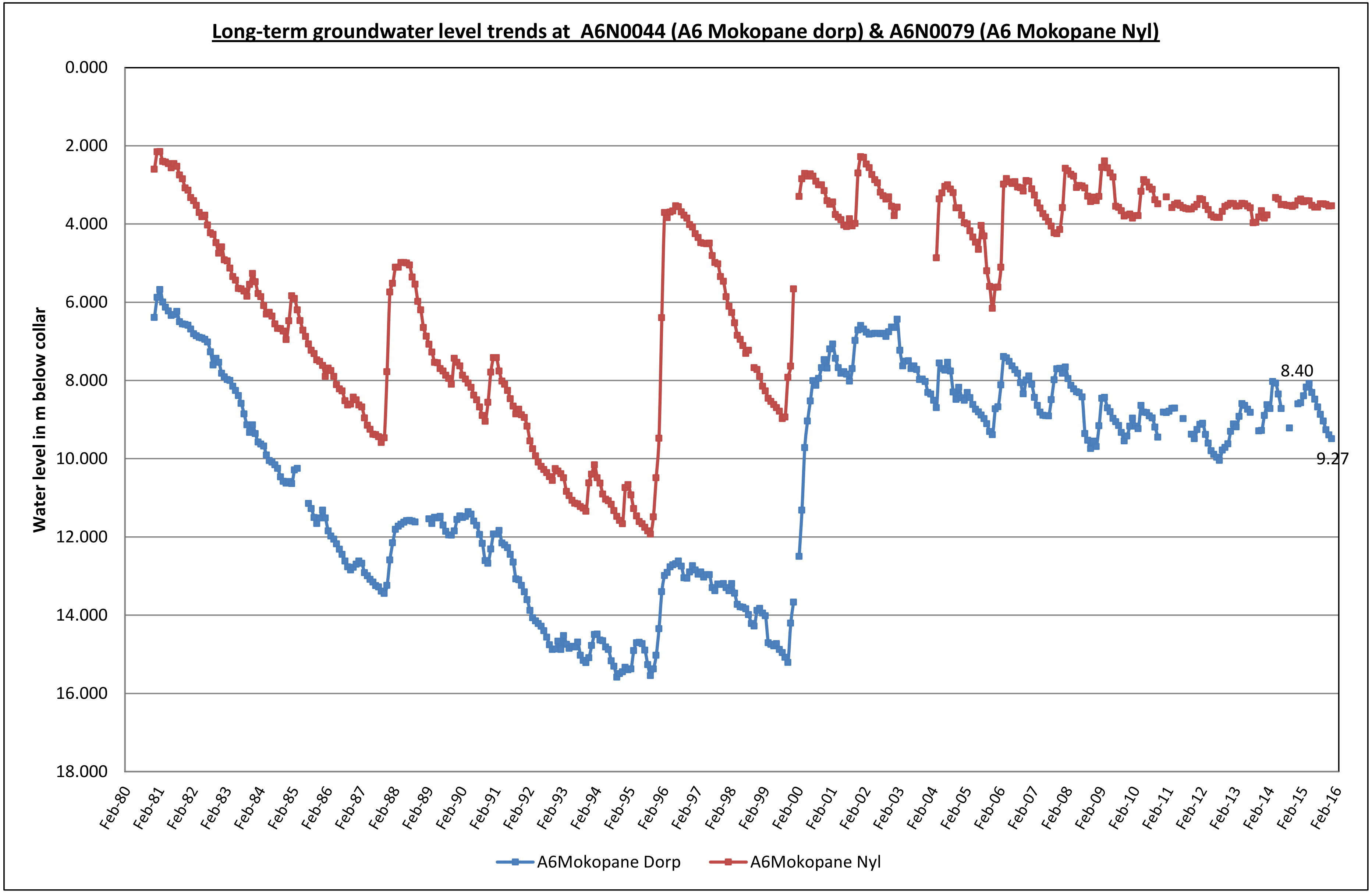


Typical groundwater level trends in the B81 part of the B8 drainage; Great Letaba River
Groundwater level in m below collar
5
6
7
8
9
10
11
12
13
14
15
800
700
600
500
400
300
200
100
0
Feb-05
Jun-05
Oct-05
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
Rainfall at Haenertsburg
Rainfall at New Agatha
Rainfall at Zomerkomst bos
B8Mphagani
B8Letsitele
B8Haenertsburg

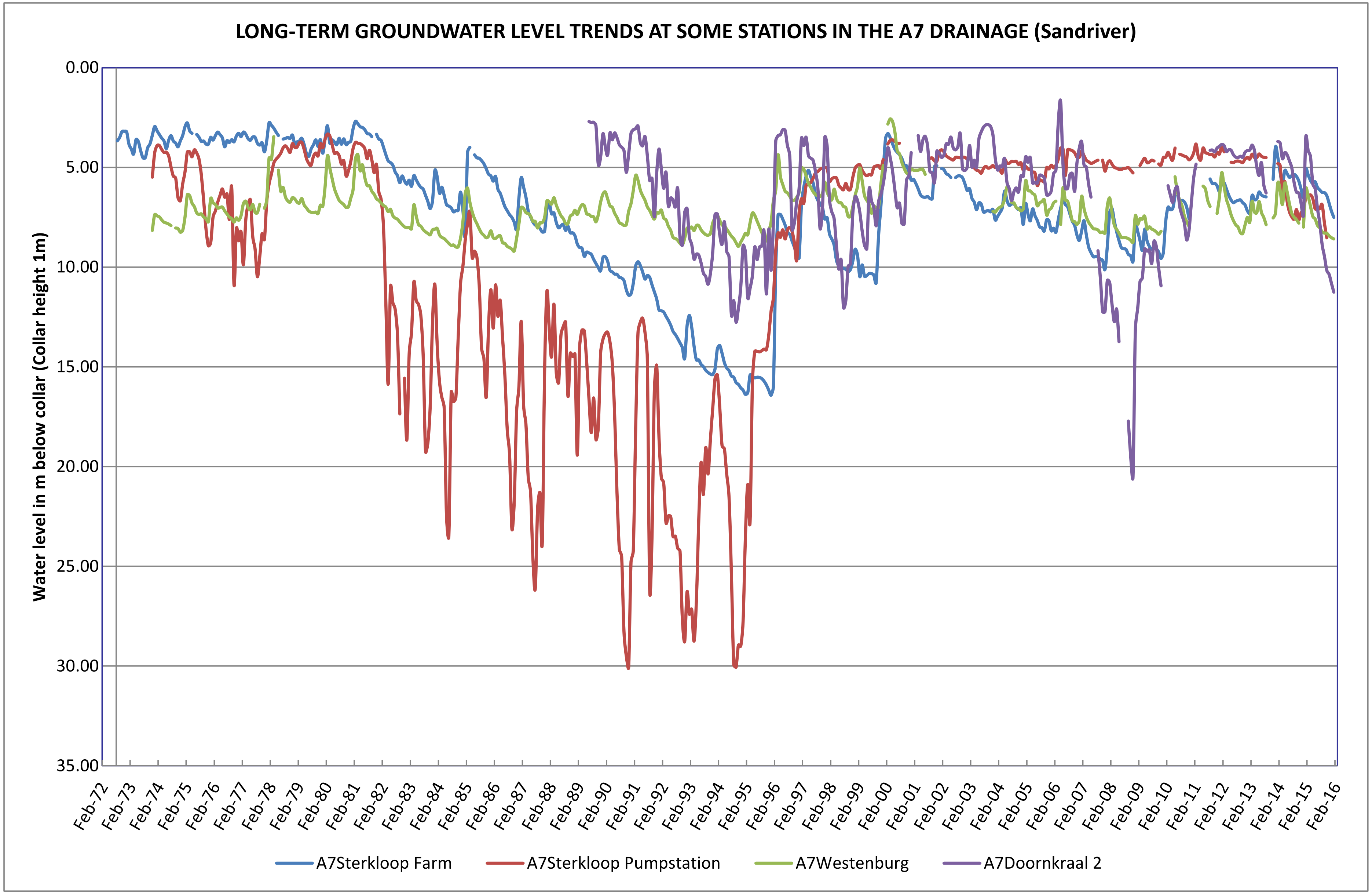
GRAPH 26


Typical groundwater level trends in the B9 drainage
Groundwater level in m below collar
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
26.00
28.00
700
600
500
400
300
200
100
0
Feb-05
Jun-05
Oct-05
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
Rainfall at Vuwani
Rainfall at Palmaryville
B9Greenfarm
B9Mukhomi
B9Halahala
B9Maphophe

GRAPH 27

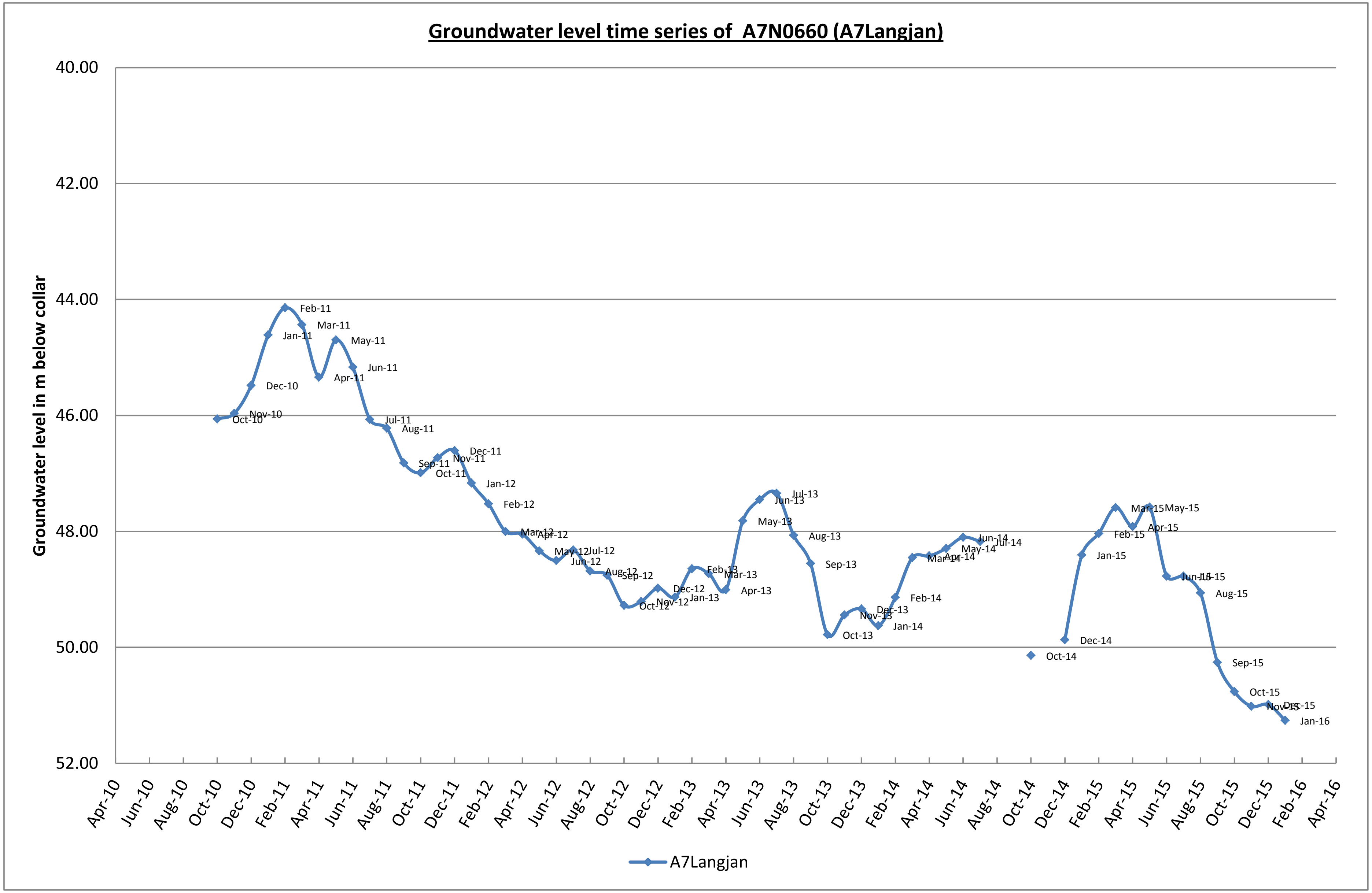

Long-term groundwater level trends at A6N0044 (A6 Mokopane dorp) & A6N0079 (A6 Mokopane Nyl)
Water level in m below collar
0.000
2.000
4.000
6.000
8.000
10.000
12.000
14.000
16.000
18.000
Feb-80
Feb-81
Feb-82
Feb-83
Feb-84
Feb-85
Feb-86
Feb-87
Feb-88
Feb-89
Feb-90
Feb-91
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
8.40
9.27
A6Mokopane Dorp
A6Mokopane Nyl

GRAPH 28

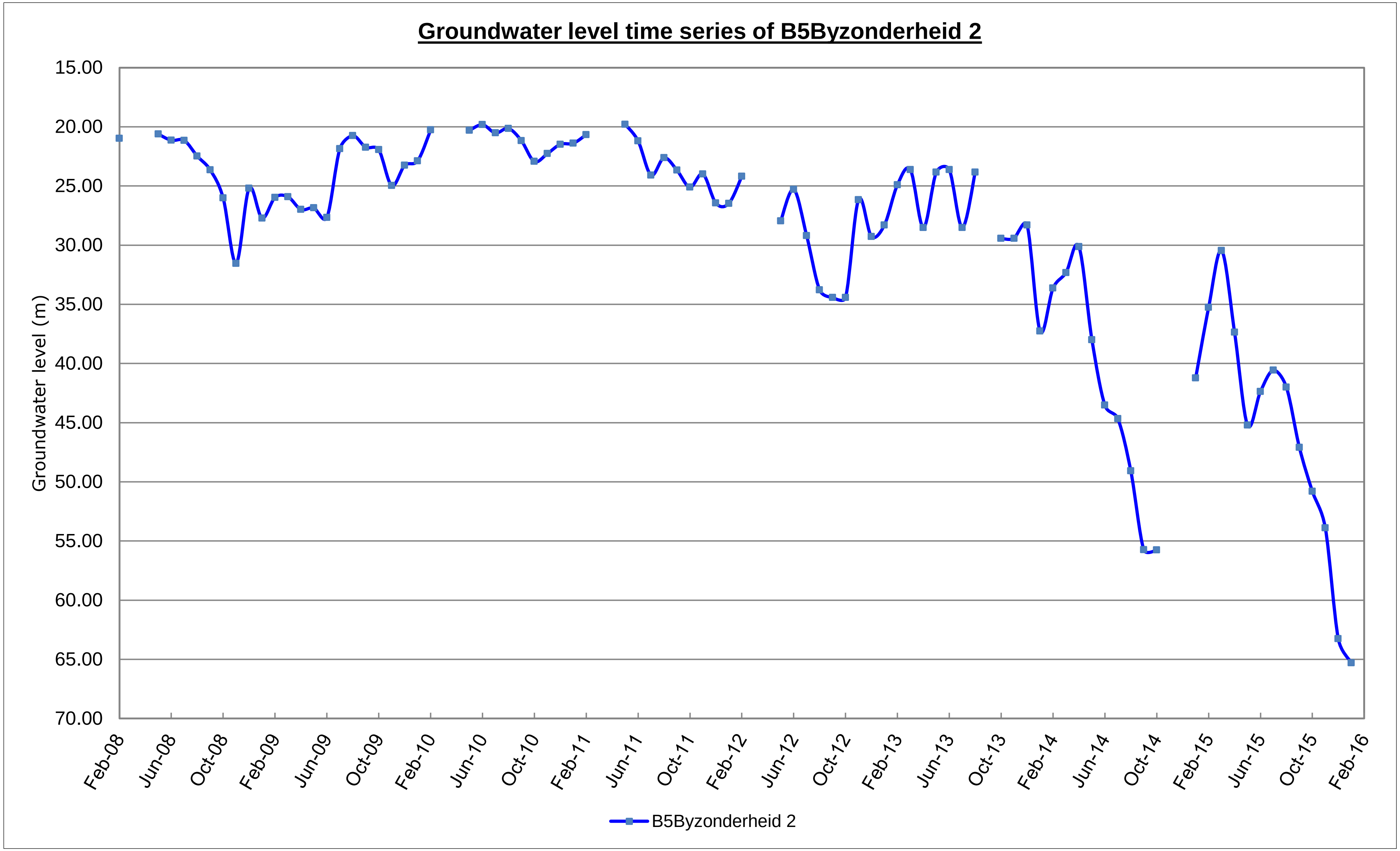


LONG-TERM GROUNDWATER LEVEL TRENDS AT SOME STATIONS IN THE A7 DRAINAGE (Sandriver)
Water level in m below collar (Collar height 1m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
Feb-72
Feb-73
Feb-74
Feb-75
Feb-76
Feb-77
Feb-78
Feb-79
Feb-80
Feb-81
Feb-82
Feb-83
Feb-84
Feb-85
Feb-86
Feb-87
Feb-88
Feb-89
Feb-90
Feb-91
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
A7Sterkloop Farm
A7Sterkloop Pumpstation
A7Westenburg
A7Doornkraal 2

GRAPH 29


Groundwater level time series of A7N0660 (A7Langjan)
Groundwater level in m below collar
40.00
42.00
44.00
46.00
48.00
50.00
52.00
A7Langjan

GRAPH 30


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
65.00
70.00
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
B5Byzonderheid 2

GRAPH 31

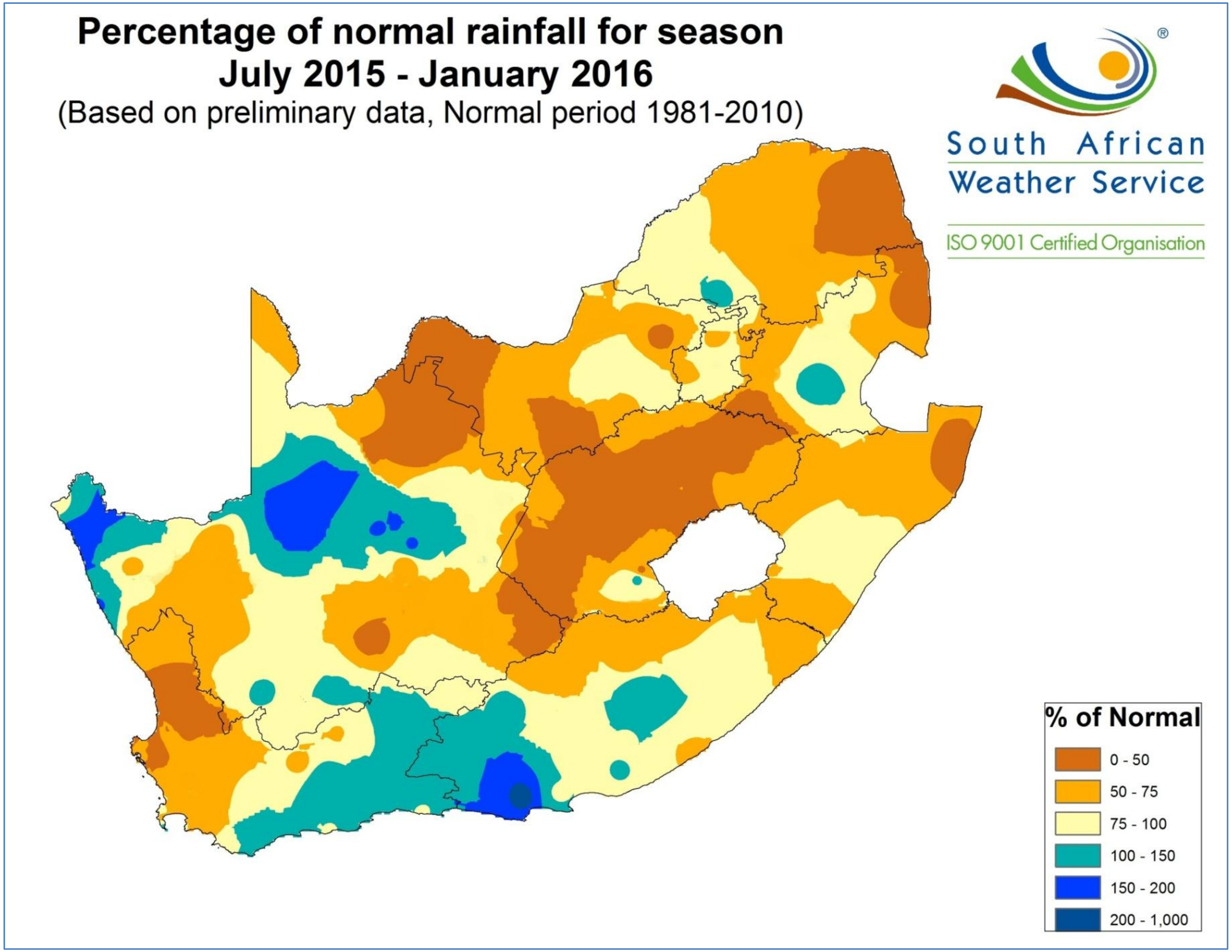

Percentage of normal rainfall for season
July 2015 - January 2016
(Based on preliminary data, Normal period 1981-2010)
South African
Weather Service
ISO 9001 Certified Organisation
% of Normal
0 - 50
50 - 75
75 - 100
100 - 150
150 - 200
200 - 1,000

FIGURE 1