RPS Aquaterra

CALGA SAND QUARRY 2010 ANNUAL INDEPENDENT GROUNDWATER AUDIT

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1. GROUNDWATER MONITORING

1.1 Background

Groundwater monitoring at Calga Sand Quarry is a requirement under Consent Condition 11 of Schedule 3 of Development Consent DA 94-4-2004 ('the Consent'), which specified the preparation of a Groundwater Monitoring Programme (GWMP).

This audit has been undertaken in response to Consent Condition 17 of Schedule 3 of the Consent issued for the operation of Calga Sand Quarry. This condition states the following:

> *'Each year from the date of this consent, or as otherwise directed by the Director-General, the Applicant shall undertake an independent audit of the groundwater impacts of the development to determine compliance with the groundwater impact assessment criteria, to the satisfaction of the Director-General. The audit shall be conducted by a suitably qualified and independent hydrogeologist whose appointment has been approved by the Director-General'.*

The groundwater impact assessment criteria are nominated in Consent Condition 10 of Schedule 3 of the Consent. Consent Condition 11 of Schedule 3 of the Consent requires the preparation of a Water Management Plan and Consent Condition 15 states amongst other things that this Plan must include:

> *'groundwater impact assessment criteria for monitoring bores and privately owned bores'.*

The Site Water Management Plan (SWMP) for the Calga Sand Quarry (Corkery, 2006) ('the Plan') details the groundwater impact assessment criteria which are listed in **Section 1.3**.

This audit report provides an independent audit review of groundwater monitoring and performance, and assesses compliance with the groundwater impact assessment criteria for the quarry. The audit was conducted by RPS Aquaterra Consulting Pty Ltd and the monitoring was undertaken by Carbon Based Environmental. The information gathering, data processing and interpretation as presented in this audit document are therefore independent of the views of Rocla. This document serves to evaluate whether there are any potential groundwater related impacts from sand extraction on water supply bores on the neighbouring properties.

The monitoring network includes 25 groundwater bores, both within the Calga site and on neighbouring properties. It served to collect data on groundwater levels and quality.

The monitoring bores and existing private production bores are located as shown on **Figure 1**, and are listed, along with bore construction details, in **Table 1.1**. For reference purposes, the table and the figure include groundwater levels recorded at the start of the review period (January 2010). In order to meaningfully interpret trends in the groundwater data the information should extend back prior to 2010. A full analysis of the trends in groundwater levels inclusive of 2010 and earlier years of monitoring, is therefore provided in **Section 3** of this report.

This audit report covers the monitoring period January to December 2010.

Private production bores within 500m of the quarry are all named with a 'CP' prefix in their bore name. Monitoring bores are named either 'CQ' for those bores that have been constructed to monitor conditions around the private production bores, or 'MW' for the monitoring bores to the south of the quarry site.

The quarry site and surrounds are depicted on **Figure 1**. The monitoring network is described separately in terms of a northern part, which includes boreholes CQ4-9 and CQ11-12 to the north of the quarry, a central area which relates to boreholes CQ1, CQ3 and CQ10 that are located at, or within the boundary of the quarry site, and a southern area that includes all of the 'MW' boreholes that are located to the south of the existing quarry site.

The monitoring bore network is broadly consistent with the list detailed in Section 6.2.3 of the Site Water Management Plan (Corkery, 2006).

1.2 Monitoring Frequency

Within the SWMP, monitoring of groundwater levels and quality is required as follows:

- Water Levels:
  - Rocla's monitoring bores (automatic recorders at a nominal 6-hourly interval).
  - Privately-owned bores (minimum of quarterly).
- Water quality:
  - On-site determination of electrical conductivity (EC) and pH every month.
  - Comprehensive laboratory analysis (including major ions and dissolved metals) every six months.

In order to satisfy these requirements, the standing water level (SWL) was measured manually on a monthly basis in all accessible bores. In addition, automatic water level recorders have been installed in fourteen of the bores, and these have been set to record the water level every 6 hours.

Each monitoring bore was also sampled monthly to determine the EC and pH, and six-monthly for comprehensive laboratory analysis.

The monitoring results are compiled into monthly Environmental Monitoring Reports (Carbon Based Environmental, 2010) which are posted on the Rocla website.

During the 2010 monitoring period, access to some sites was limited, as follows:

- Access was not granted to conduct any monitoring or sampling from either CP1 or CP2 (Gazzana production bores).
- Access to bore CP8 on the Rozmanec property was limited to six monthly water quality sampling. It was not possible to obtain a six monthly sample for full analytical testing for bore CP4 (Kashouli) during the April 2009 monitoring round.

1.3 Groundwater Impact Assessment Criteria

The interim groundwater impact assessment criteria are detailed in Section 6.4 of the Plan. The criteria come under aspects of groundwater levels and groundwater quality and are detailed below.

Groundwater Levels

- If at any annual independent audit review, there is a declining trend in groundwater levels which is not attributable to climatic conditions or other factors not related to sand extraction, and if the groundwater level decline at monitoring bores CQ10 or CQ11 deemed due to sand extraction impacts exceeds 1.0m, then the adjoining landowners will be approached to arrange re-testing of their existing production bore(s). The test results will be compared to pre-extraction tests, and if it is determined that any bore has suffered a reduction in its pumping yield of greater than 10% then action will be taken as described in the Plan; and
- If at any other time, a landholder's bore within 500m of the quarry suffers a reported loss of yield greater than 10% due to declining groundwater levels, the loss of yield would be notified to both the Director-General and affected landholders. The Company would also commission an independent hydrogeologist to conduct an investigation regarding the loss of yield. The investigation would include a review of all monitoring data, and if necessary a re-testing of the bore to allow comparison of performance with previous tests. If the investigation reveals that the loss of yield is attributable to the sand extraction activities, then arrangements would be made with the landholder to restore the supply by one of the means described in the Plan.

Groundwater Quality

- If any private bore within 500m of the quarry experiences a salinity increase (20% increase in EC or TDS), response actions would be implemented as detailed in the Plan.

1.4 Impact Assessment Methodology

It should be noted that both groundwater levels and groundwater quality demonstrate significant natural background variation. Groundwater levels vary according to climatic conditions (intermittent rainfall recharge and continuous natural discharge), and variations in groundwater levels, flows and recharge cause natural fluctuations in groundwater quality. This means that there are no single groundwater level or groundwater quality values that can be used as baseline values for comparison purposes. Rather, the assessment of impacts has to be based on changes greater or less than the natural variations.

The assessment of potential impacts used in this audit was therefore based on trend analyses. The groundwater trends were analysed to determine if there have been any variations across the monitoring network that indicate:

- *Spatial differences*. Groundwater hydrographs and water quality charts were examined to determine whether there were differences between the trends in monitoring bores that are located close to the quarry, and the monitoring bores that are located further away from the quarry. Any significant variation in patterns could indicate an impact from the quarry activities.
- *Temporal (time related) differences.* Groundwater levels follow a pattern whereby they increase following rainfall recharge, and then decrease due to natural discharge in line with their natural 'recession rate'. The nature of the recession rate was therefore examined to determine if it has changed over time, which could be indicative of impacts from the quarry. Groundwater quality also varies naturally over time, so the long term water quality trends were examined to determine if there are any consistent changes in groundwater quality that could be indicative of a change in the groundwater regime and hence quarrying impacts.

Attention was also given to assessing whether any impacts from operation of the private bores themselves were detected at any of the monitoring bores.

The monitoring data have therefore been compared using the trend analysis approach to determine if quarrying related impacts have exceeded any of the criteria. The trend analyses for groundwater levels and water quality monitoring are described in **Sections 3** and **4** respectively**.**

Table 1.1: Monitoring Bores and Private Production Bores* Construction and Location Details

Bore	Old Name	Location (MGA)		Ground Level (mAHD)	Stick-up (m)	Bore Depth (m)	Groundwater Production Interval(s)		Screen Interval		Water Level (Jan 2010)	
		Easting	Northing				(mBGL)	(mAHD)	(mBGL)	(mAHD)	(m below TOC)	(mAHD)
CP1	PB1	333543	6301911	193.53	0.02	60.9	NR		-			
CP2	PB2	333559	6302042	198.75	0.12	40.0	11–13	185–188	-			
CP3	Gazzana Domestic Bore	334069	6301873	215.95	0.15	76.2	NR		-		8.65	207.45
CP4	-	334121	6301830	est 218		44.0	13.9-14.1 27.3-27.7	205 191	*Open hole*		11.05	206.95
CP5	-	334057	6302043	est 218		76.0	10.1–10.2 20.4–20.5 38.3–38.6 61.2–61.3		*Open hole*		10.52	207.48
CP6	-			est 215		92.0	16.5–16.8 62.7–63.0 76.2–76.5		*Open hole*		24.84	190.16
CP7	-	333967	6302048	est 205		76.2	4.8–39.5		*Open hole*		3.79	201.21
CP8	Rozmanec	334771	6301553	est 225		?	20.6–20.7 44.3–44.6	184 160	*Open hole*			
CQ1	-	334506	6301417	221.405	0.73	27.6			24.1–27.1	194.3–197.3	19.84	202.295
CQ2	-	Bore decommissioned in April 2008 – located within approved extraction area										
CQ3	-	333723	6301299	180.451	0.57	21.8			18.3–21.3	159.2–162.2	10.63	170.391
CQ4	-	334150	6301799	214.826	0.68	20.0			16.4–19.4	195.4–198.4	8.33	207.176
CQ5	G31	333898	6301649	212.7	0.83						6.96	206.57
CQ6	G32	333737	6301712	206.6	0.87						11.75	195.72
CQ7	G33	333950	6301683	204.3	0.85	29.7			20.7–26.7	177.6–183.6	7.27	197.88

Table 1.1: Monitoring Bores and Private Production Bores* Construction and Location Details

Bore	Old Name	Location (MGA)		Ground Level (mAHD)	Stick-up (m)	Bore Depth (m)	Groundwater Production Interval(s)		Screen Interval		Water Level (Jan 2010)	
		Easting	Northing				(mBGL)	(mAHD)	(mBGL)	(mAHD)	(m below TOC)	(mAHD)
CQ8	G34	333790	6301778	200.9	0.86	26.6			17.7–23.7	177.2–183.2	6.82	194.94
CQ9	G35										9.48	181.3
CQ10D	-			~212		57.0			51–57	155–161	22.7	189.3
CQ11S	-	334172	6301827	~220		38.0			32–38	182–188	9.75	210.25
CQ11D	-	334164	6301825	~220		65.0			59–65	155–161	11.06	208.94
CQ12	-	333800	6301805	~201		15.0			9–15	186–191	5.12	195.88
CQ13	-	334131	6301922	~220		65.0			59–65	155–161	14.15	205.85
MW7	-	334506	6300226	209.92	0.87	30.0					16.75	194.04
MW8	-	334011	6300298	191.03	0.88	30.0					8.23	183.68
MW9	-	334543	6301387	223.56	0.88	27.0					21.84	202.6
MW10	-	333716	6300992	163.14	0.87	30.0					15.48	148.53
MW13	-	334236	6300819	178.42	0.89						8.31	171
MW16	-	334027	6300943	173.67	0.89						8.9	165.66

*Private production bores located within 500m of the quarry have a 'CP' prefix in their bore name.

MGA means metric triangular grid system, its unit of measure is the metre and identifies unique locations in Australia

AHD means the Australian Height Datum and is a reference to the elevation in metres relative to 0m AHD (which is roughly sea level)

mBGL means metres below ground level. TOC means top of the casing of the bore

2. RAINFALL AND EVAPORATION

Monthly rainfall and evaporation data from the nearest Bureau of Meteorology site (Peats Ridge - BoM Station No. 061351) and data collected at Calga Quarry is presented in **Table 2.1**. Rocla Quarry site has been recording daily rainfall events at the Calga Quarry since April 2006.

During the 2010 reporting period, rainfall totals for the nearest Bureau of Meteorology Station Peats Ridge site showed cases of similar values compared with long-term average (LTA) as well as other cases with up to 52% difference in values. Total rainfall at Calga for the period January – December 2010 was 1130.7 mm, compared with 1194.8 mm at the BoM Peats Ridge gauge (**Table 2.1**). The Peats Ridge total was slightly less than the long-term average total rainfall (1210.5 mm) by 1.3%.

Evaporation data from Peats Ridge BoM Station was consistent with previous years although the minimum evaporation observed in 2010 (29.2) was lower than in previous reporting periods.

Table 2.1: Monthly Rainfall and Evaporation

Month	Total Rainfall (mm)		Total Evaporation (mm)	
	Calga Quarry	Peats Ridge*	Peats Ridge* Long-Term Average	Peats Ridge* 2009
Jan 2010	62.5	94.0	116.4	117.7
Feb 2010	143.4	152.2	161.8	74.9
Mar 2010	127.8	135.8	138.5	78.8
Apr 2010	54.6	59.6	125.4	61.4
May 2010	122.4	94.6	97.9	44.8
Jun 2010	111.0	116.2	50.3	29.2
Jul 2010	47.4	66.3	65.7	33.4
Aug 2010	32.8	44.4	82.5	60.6
Sep 2010	36.4	35.6	75.1	73.6
Oct 2010	94.6	103.2	91.0	69.4
Nov 2010	180.2	204.5	110.6	92.3
Dec 2010	117.6	88.4	94.9	93.9
Total Jan-Dec 2010	**1130.7**	**1194.8**	**1210.5**	**830.2**

*Bureau of Meteorology (BoM) Station No. 061351. Long-term averages derived from 29-year period 1981-2010.

3. GROUNDWATER LEVELS

3.1 Summary

Groundwater levels are presented graphically as hydrographs, along with rainfall and evaporation data, in **Figures 3** to **11**.

During earlier review periods (January 2007 – December 2008) substantial rainfalls above the LTA (as shown for the BoM site at Peats Ridge) resulted in a general rise in groundwater levels across the monitoring network. This was followed by a recession in groundwater levels towards the end of 2008, which was associated with a period of reduced rainfall.

For the immediate previous reporting period (January to December 2009), groundwater levels showed a general increase in elevation from February 2009 to June 2009, followed by a recession in groundwater levels during the June 2009 to December 2009 period.

In the reporting period (January to December 2010), precipitation has been generally below the LTA (excluding May, November and December 2010). August and September were quite dry while the evaporation is on the rise (**Figure 2**). Groundwater levels show patterns similar to the rainfall and are, in the main, stable during the reporting period.

All monitoring areas showed the same seasonal rainfall driven responses, with recharge events visible in most hydrographs in February, May-June and November-December 2010, and normal recession trends observed in the intervening periods. There were no noticeable deviations from past patterns of recharge, and past recession trends, that would suggest dewatering of specific groundwater areas.

The same types of responses were seen in bores located close to, and bores more distant from, the quarry site.

The very close correlation between rainfall and hydrographs, and the lack of differential trends between the various parts of the monitoring system, clearly shows that there is no evidence of any adverse impacts on groundwater levels from the quarry operations during 2010.

3.2 Specific Observations

Bores CQ1 to CQ4 have been monitored since 2001, and provide a long-term record of groundwater level fluctuations. These bores are located within the quarry area, CQ1 at the south-east corner of the quarry site, CQ3 near the south-western corner, CQ2 in the centre and CQ4 at the northern boundary.

Hydrographs of bores CQ1, CQ2, CQ3 and CQ4 for the period 2001 to 2010 are presented on **Figures 3** and **4**. CQ2 was read up until March 2008, when the bore was lost as the quarry expanded into that area.

Between 2001 and 2007, all four hydrographs showed a pattern of declining water levels, with periodic sharp rises following recharge events. However, there was an overall decline in levels through this period. A major recharge event in mid-2007 restored groundwater levels at CQ3 and CQ4 back to the levels prevailing in 2001, but did not fully restore groundwater levels at CQ1 or CQ2. At CQ1 and CQ2, the water levels reached after the 2007 recharge event were 1-1.5m below the 2001 levels, indicating a small net decline in levels.

The pattern at CQ4 and CQ3 indicates that the declines in water level seen prior to 2007 were entirely due to rainfall recharge being insufficient in those years (apart from June 2007) to restore groundwater levels, and were not due to the operation of the quarry. However, the patterns seen at CQ1 and CQ2 suggest that some of the decline pre-2007 was due to mining impact. A net drawdown of around 1-1.5m due to the sand extraction operation is indicated at those two bores.

The hydrograph pattern displayed at bore CQ4 indicates an active recharge-discharge regime, with natural discharge occurring as a continuous process, and recharge occurring as an intermittent process following significant rainfall events, with smaller events partially restoring groundwater levels, and the major events like June 2007 returning the aquifer to full storage. Since 2007, the hydrograph pattern is similar to the pre-2007 pattern, with no evidence of any decline due to sand extraction operations.

The pattern at CQ3 was similar until mid 2004, but thereafter water levels in this bore have been close to historic levels, and the hydrograph suggests that the area occupied by CQ3 is being recharged by seepage from the dams at the western end of the quarry site. The datalogger records for CQ3 between May 2006 and February 2008 show regular short-term drawdown response each time the bore was bailed for water sampling, and slow recovery over a period of several days. The slowness of this response indicates that the sandstone at this site is poorly permeable, as normally collection of water samples has a negligible effect on a monitoring bore. Only the monthly manual data are plotted for the period since February 2008.

CQ1 and CQ2 (until mined out) showed partial recovery after June 2007. There is no evidence at CQ1 of any further net decline in groundwater levels due to sand extraction since 2007.

The hydrographs for monitoring bores CQ5, CQ6, CQ7, CQ8 and CQ9, which are located to the north of the quarry, are shown in **Figures 5** and **6**.

Hydrographs for CQ10 which is located to the east of the quarry, and CQ11S and D, north of the quarry, are shown on **Figure 7**. CQ12 and CQ13, both north of the quarry, are shown on **Figure 8**.

CQ11S and D (**Figure 7**), and in particular CQ13 (**Figure 8**) have, in past reporting periods, all shown a response to nearby pumping from one or more of the private production bores. Groundwater levels in CQ13 showed the most significant response, related to the impact of pumping from the adjacent Kashouli Bore CP4.

Apart from the above responses to pumping of the private bores, there is no evidence in the hydrographs of bores located outside the quarry boundary of any impact from other than natural rainfall recharge and natural discharge.

Water levels of monitoring bores MW7, MW8, MW9, and MW10 within the southern area (**Figures 9** and **10**), south of the existing quarry, also exhibited very similar trends to those seen in the northern area, with generally lower water levels than observed in 2009 but higher than 2006. No significant recharge or recession was noted, and no impacts attributable to the quarry operations. The hydrograph for MW9 (**Figure 9**), located near CQ1, shows a similar pattern to CQ1, and similar elevation, and on this basis, the MW9 site has also probably seen a slight net drawdown from the quarry operations, prior to 2007.

There is no evidence of any impact on groundwater levels from the quarry operations other than at bores CQ1 and CQ2, both located within the quarry itself. The largest net drawdown is that observed at CQ1, where the groundwater level in 2010 was around 202-203 mAHD, well above the quarry floor level of 190 mAHD in the main pit, just 80m to the west of the bore. The water level this high above the quarry floor indicates that the drawdown “cone” of depression is very limited in area, and probably does not extend beyond the quarry boundary.

Manual monthly readings of depth to water level taken in domestic water-supply bores CP3 to CP8 are shown in **Figure 11**. As these bores are active production bores, the recording of manual data was subject to significant variations depending on when during the pumping cycle the reading is taken. During 2010, the water levels in all bores remained static with pumping-affected draw-downs generally less than in previous years. The exception to this general trend was CP6 with a major draw-down in January 2010 due to pumping. The recovery was notably rapid which underlines high permeability in the CP6 area. The overall pattern of recharge and recession was similar to the monitoring bore network described above.

3.3 Compliance Assessment of Groundwater Levels

An assessment of compliance has been undertaken against the two impact assessment criteria for groundwater levels described in **Section 1.3**, using the impact assessment methodology described in that section. The assessment is based on the trend analysis described in **Sections 3.1.** and **3.2.** The findings of this assessment are detailed below in **Table 3.1**.

Table 3.1: Compliance Assessment for Groundwater Levels

Impact Assessment Criteria	Compliance Assessment Findings
If at any annual independent audit review, there is a declining trend in groundwater levels which is not attributable to climatic conditions or other factors not related to sand extraction, and if the groundwater level decline at monitoring bores CQ10 or CQ11 deemed due to sand extraction impacts exceeds 1.0m, then the adjoining landowners will be approached to arrange re-testing of their existing production bore(s). The test results will be compared to pre-extraction tests, and if it is determined that any bore has suffered a reduction in its pumping yield of greater than 10% then action will be taken as described in the Plan.	• Groundwater levels across the site in all bores varied in response to climatic conditions, and there were no noticeable deviations that would suggest impact from quarrying activities on any bore outside the quarry boundaries. • The locations of the landholders' bores are as shown on **Figure 1**, and include all bores with a 'CP' prefix. Bores CQ5 to CQ13 were installed between the private bores and the quarry, and were screened at depths similar to those screened in the relevant private bores. These act as appropriate monitoring bores for all private bores within 500m of the quarry. • All groundwater level changes observed in these bores were directly related to climatic conditions, and showed no appreciable difference in climatic response to bores that were located at much greater distances from the quarry. There were no detectable trends that are not directly attributable to climatic conditions. Groundwater levels remain well above the baseline values recorded in 2006, and within 1m of the values recorded at the start of the review period. • There were no impacts from the sand quarrying that might exceed 1m in bores CQ10 or CQ11, so there was no cause to approach the landowners for re-testing during the monitoring period. • Based on the above, it is considered that quarry activities are in compliance with this impact assessment criterion.
If at any other time, a landholder's bore within 500m of the quarry suffers a reported loss of yield greater than 10% due to declining groundwater levels, the loss of yield would be notified to both the Director-General and affected landholders. The Company would also commission an independent hydro-geologist to conduct an investigation regarding the loss of yield. The investigation would include a review of all monitoring data, and if necessary a re-testing of the bore to allow comparison of performance with previous tests. If the investigation reveals that the loss of yield is attributable to the sand extraction activities, then arrangements would be made with the landholder to restore the supply by one of the means described in the Plan.	• Because there were no noticeable trends associated with quarrying impacts in bores CQ5 to CQ13, there was no evidence of impact and hence no requirement to investigate the private bores. • In 2010, none of the landowners who have bores within 500m of the quarry reported a loss of yield from their bores. • Based on the above, it is considered that quarry activities are in compliance with this impact assessment criterion.

In summary, the operation of the quarry was in compliance with the groundwater level impact assessment criteria throughout 2010.

It is noted that datalogger records of groundwater levels are not available for bores CQ1, CQ3 and CQ13 for the 2010 year, and only manual monitoring data are available. Accordingly, 6-hourly water levels (as required by the Site Water Management Plan) are not available for these three bores for 2010.

4. GROUNDWATER QUALITY

4.1 Evaluation

Field measurements of electrical conductivity (EC) and hydrogen ion activity (pH) were recorded monthly from all accessible bores. A summary of the field sampling results is provided in **Table 4.1** which shows average results from the data collected during the 2010 monthly sampling program.

Samples for comprehensive laboratory analysis were collected in April and October 2010. The results of laboratory analysis are presented in **Tables 4.2** and **4.3**. Laboratory and field data have generally shown consistency across the monitoring period.

Table 4.1: Calga Monitoring and Production Bores – Average of 2010 Monthly Field Data

Reference*	Land Owner	Annual Average of Recorded Monthly Field Data	
		pH	EC (µS/cm)
CQ1	Rocla	4.6	120.0
CQ3	Rocla	6.0	114.2
CQ4	Rocla	4.6	80.0
CQ5	Gazzana	4.2	150.8
CQ6	Gazzana	4.4	174.2
CQ7	Gazzana	4.4	91.6
CQ8	Gazzana	4.2	152.5
CQ9	Gazzana	4.3	105.0
CQ10	Rocla	5.3	168.3
CQ11S	Gazzana	4.4	148.3
CQ11D	Gazzana	5.1	127.5
CQ12	Gazzana	4.2	132.5
CQ13	Kashouli	5.0	180.0
CP3*	Gazzana	4.4	141.7
CP4*	Kashouli	5.0	207.5
CP5*	Kashouli	4.4	238.3
CP6*	Kashouli	4.2	205.0
CP7*	Kashouli	4.7	165.0
CP8*	Rozmanec	4.2	150.0
MW7	Rocla	4.7	111.6
MW8	Rocla	4.7	80.9
MW9	Rocla	4.6	83.3
MW10	Rocla	4.2	125.8
MW13	Rocla	4.8	97.5
MW16	Rocla	4.4	107.5

Note: Bores denoted * are production bores within 500m of the extraction area of the Calga Sand Quarry

The EC data collected for the 2010 reporting period showed generally low concentrations of dissolved ions, with values ranging from 80 to 207 µS/cm. Groundwater is naturally weakly acidic with the pH typically ranging from pH 4 to pH 6, which is outside of the NHMRC & NRMMC (2004) aesthetic guidelines for Drinking Water Quality. This remains consistent with previous years.

Trend analyses for EC and pH are shown in **Figures 12** to **15**, and include trends of all the field data gathered to date. The analysis has been grouped within the following geographical areas:

- **Figure 12** shows EC and pH trends for boreholes CQ1, CQ3 and CQ10 which are located in the central area of the monitoring network. Although EC and pH values in this area showed some variation, the scale of variation was less than that seen in the other areas. CQ10 shows a spike in EC which appears to be anomalous.

- **Figure 13** shows EC and pH trends for boreholes CQ4 – 9 and CQ11 - 12, located to the north of the quarry. EC and pH show a similar pattern to previous years.
- **Figure 14** shows EC and pH trends for boreholes MW7 - 10, located to the south of the quarry. EC values are generally stable during 2010. Minor fluctuations are believed to be related to rainfall events.
- **Figure 15** shows EC and pH trends for domestic water-supply bores CP3 – 8, located to the north and east of the quarry. EC levels in CP3 and CP8 remained generally low and stable. CP7 shows a continuous decrease through 2010 while CP5 shows a strong correlation with the rainfall and decreases in EC following increased rainfall. CP6 and CP4 stay very similar and stable through 2010 with slight increase in December. pH values show a mild increasing trend, however CP4 had an elevated pH reported in April.

Concentrations of some dissolved metals were elevated relative to ANZECC (2000) guidelines for freshwater ecosystem protection (95%), as summarised in **Table 4.4**. These are reflective of the natural groundwater quality, and the type and number of exceedances has been broadly constant over the period of monitoring. **Table 4.5** shows the number of exceedances according to metal type across the monitoring network during the full monitoring period. It seems that natural concentrations of aluminium, copper, lead and zinc regularly exceed the ANZECC (2000) guidelines, however, there has been no significant trend over time in the number of exceedances of other metals that have been recorded.

Several of the groundwater samples reported elevated nitrate concentrations, ranging up to 20.6 mg/L in CP5 in April 2010, compared with the ANZECC (2000) freshwater ecosystem protection guideline value of 0.7 mg/L. The concentrations greater than 10 mg/L exceed the Australian Drinking Water Guideline Value (NHMRC & NRMMC, 2004), which is quoted as 50mg/L as NO_3. The results were generally comparable with those reported during the previous reporting periods.

Figure 16 shows nitrate trends in monitoring bores grouped according to area. This shows that all of the high nitrate levels were recorded in the domestic production bores and in the adjacent monitoring bores north of the quarry site. These high nitrate values were almost certainly associated with farming activities in that area, due to either fertiliser use or chicken farming. Nitrate levels in this area have been historically very variable.

Due to the lack of any trend in the number of exceedances of metals and nitrates, it is recommended that sampling and laboratory analysis of water quality are reduced to an annual monitoring round. Given the lack of any exceedances of the ANZECC (2000) standards for arsenic, manganese, selenium and boron throughout the monitoring period, it is recommended that these parameters are removed from the analytical suite of tests.

4.2 Compliance Assessment of Groundwater Quality

The only compliance criterion for groundwater quality is that response actions should be initiated if any private bore within 500m of the quarry experiences a salinity increase of 20% or more. Based on the impact assessment methodology described in **Section 1.3**, and the trend analysis described in **Section 4.1**, there have been no adverse trends in water quality within the monitoring network that could be attributed to the quarry. As shown in **Figure 15**, all private bores showed a generally stable trend in salinity (EC) during the current reporting period. By the end of 2010, most of the private bores showed salinity (EC) levels that were at, or lower than the baseline (2006) conditions. CP7 showed a continuing decrease in EC during 2010, and EC values are now lower than the EC values in 2006.

In broad terms, the salinity has remains very stable or it has decreased in 2010 and there are no indications of increasing salinity within or around the quarry in this reporting period.

Based on the above, it is considered that the quarry activities were in compliance with this criterion throughout 2010.

Table 4.2: Calga Monitoring and Production Bores – Six Monthly Laboratory Water Analysis Results (April 2010)

Bore		***Guideline Values for Freshwater Ecosystem Protection* or Drinking Water Quality*****	**CQ1**	**CQ3**	**CQ4**	**CQ5**	**CQ6**	**CQ7**	**CQ8**	**CQ9**	**CQ10**	**CQ11S**	**CQ11D**	**CQ12**
Parameter	**Units**													
pH Value		6.5 – 8.5	4.31	5.99	4.89	4.32	4.67	4.57	3.48	4.41	4.61	4.57	5.29	4.38
Conductivity @ 25°C	µS/cm	-	138	134	109	170	218	109	172	122	175	169	144	156
Calcium	mg/L	-	<1	2	<1	4	2	<1	<1	<1	2	<1	1	<1
Magnesium	mg/L	-	3	4	1	4	11	2	6	2	3	5	3	5
Sodium	mg/L	180	12	12	12	12	11	12	15	13	17	15	15	13
Potassium	mg/L	-	<1	1	<1	2	2	<1	<1	<1	<1	4	<1	<1
Hydroxide Alk as CaCO3	mg/L	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alk as CaCO3	mg/L	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alk as CaCO3	mg/L	-	3	25	5	<1	<1	<1	<1	<1	<1	<1	7	<1
Sulphate	mg/L	250	15.9	3.04	8.59	30.5	9.9	5.52	6.62	5.47	24.3	35.4	22.8	28.9
Chloride	mg/L	250	20.4	21.3	18.2	20.6	20.7	22.4	19.9	26.8	27.2	15.4	18	18.2
Aluminium - Filtered	mg/L	*0.055*	0.48	0.14	0.08	0.87	1.87	0.17	0.62	0.2	0.87	0.93	0.07	0.84
Arsenic - Filtered	mg/L	*0.013*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium - Filtered	mg/L	*0.0002*	<0.0001	0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
Chromium - Filtered	mg/L	*ID*	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001
Copper - Filtered	mg/L	*0.0014*	0.002	0.003	0.006	<0.001	0.009	<0.001	0.002	0.002	0.005	0.003	<0.001	0.002

Bore / **Parameter**	**Units**	***Guideline Values for Freshwater Ecosystem Protection* or Drinking Water Quality*****	**CQ1**	**CQ3**	**CQ4**	**CQ5**	**CQ6**	**CQ7**	**CQ8**	**CQ9**	**CQ10**	**CQ11S**	**CQ11D**	**CQ12**
Lead - Filtered	mg/L	*0.0034*	0.001	0.002	0.004	0.001	0.004	0.001	0.002	0.001	0.017	0.03	0.006	0.007
Manganese - Filtered	mg/L	*1.9*	0.006	0.821	0.004	0.007	0.021	0.003	0.002	0.002	0.024	0.007	0.035	0.002
Nickel - Filtered	mg/L	*0.011*	0.003	0.011	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.004	0.001	0.003	<0.001
Selenium - Filtered	mg/L	*0.011*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc - Filtered	mg/L	*0.008*	0.013	0.104	0.032	0.02	0.124	0.016	0.02	0.009	0.082	0.066	0.118	0.04
Boron - Filtered	mg/L	*0.37*	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron - Filtered	mg/L	*ID*	0.08	0.36	<0.05	<0.05	0.44	<0.05	<0.05	0.06	0.11	0.06	0.3	<0.05
Mercury - Filtered	mg/L	*0.0006*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride as F	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	0.03	<0.02	0.03	<0.02
Nitrite as N	mg/L	<0.01	0.02	<0.01	0.02	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N***	mg/L	1.09	0.09	0.37	1.16	12.4	1.23	8.66	1.07	1.36	0.11	0.02	0.59	1.09

* *Italics represent ANZECC (2000) 95 percentile standards for Freshwater Ecosystems*

** Non-italics represent NHMRC & NRMMC (2004) drinking water guidelines for aesthetics

*** Nitrate NHMRC & NRMMC (2004) Australian Drinking Water Guideline Value is 50mg/L

0.00 Highlighted cells indicate exceedances of the ANZECC guideline standards

Bore		*Guideline Values for Freshwater Ecosystem Protection* or Drinking Water Quality***	CQ13	CP3	CP5	CP6	CP7	CP8	MW7	MW8	MW9	MW10	MW13	MW16
Parameter	**Units**													
pH Value		6.5 – 8.5	5.05	4.63	4.3	4.25	5.44	4.26	4.4	4.72	4.43	4.5	3.52	4.52
Conductivity @ 25°C	µS/cm	-	209	158	275	230	185	160	127	105	96	146	109	122
Calcium	mg/L	-	<1	<1	1	<1	8	<1	<1	<1	<1	1	<1	<1
Magnesium	mg/L	-	6	3	15	10	4	3	2	2	1	2	2	2
Sodium	mg/L	180	24	16	14	16	6	17	14	11	11	15	12	14
Potassium	mg/L	-	<1	1	1	<1	13	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alk as CaCO3	mg/L	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alk as $CaCO_3$	mg/L	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alk as $CaCO_3$	mg/L	-	2	<1	<1	<1	4	<1	1	3	<1	<1	<1	<1
Sulphate	mg/L	250	3.94	27.6	3.35	6.02	20.9	7.66	5.88	6.32	5.24	9.5	5.43	4.97
Chloride	mg/L	250	33.8	21.2	23.7	22.5	12.3	32.2	28.4	22.2	21.5	30.6	26.4	30.8
Aluminium	mg/L	*0.055*	0.39	0.48	0.98	0.94	0.09	0.98	0.29	0.28	0.17	0.79	0.09	0.22
Arsenic	mg/L	*0.013*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	*0.0002*	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	*ID*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	*0.0014*	0.004	0.229	0.01	0.016	0.003	0.007	0.001	0.003	<0.001	0.003	0.003	0.004

Bore														
Parameter	**Units**	***Guideline Values for Freshwater Ecosystem Protection* or Drinking Water Quality*****	**CQ13**	**CP3**	**CP5**	**CP6**	**CP7**	**CP8**	**MW7**	**MW8**	**MW9**	**MW10**	**MW13**	**MW16**
Lead	mg/L	*0.0034*	0.056	0.015	0.002	0.001	<0.001	0.002	0.002	0.004	<0.001	0.006	0.004	0.002
Manganese	mg/L	*1.9*	0.011	0.004	0.002	0.002	0.206	0.008	0.008	0.007	0.003	0.015	0.052	0.01
Nickel	mg/L	*0.011*	0.001	0.001	<0.001	0.001	<0.001	<0.001	0.001	0.002	<0.001	0.002	0.002	0.001
Selenium	mg/L	*0.011*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	*0.008*	0.088	0.194	0.006	0.078	0.052	0.063	0.011	0.038	0.006	0.087	0.078	0.015
Boron	mg/L	*0.37*	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	*ID*	0.08	0.46	<0.05	<0.05	0.66	0.16	0.11	0.1	<0.05	<0.05	<0.05	<0.05
Mercury	mg/L	*0.0006*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride as F	mg/L	-	<0.02	0.03	0.03	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrite as N	mg/L	3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	*0.7*	9.03	1.22	20.6	13.9	8.8	2.55	0.18	0.07	0.22	0.38	0.41	0.14

* *Italics represent ANZECC (2000) 95 percentile standards for Freshwater Ecosystems*

** Non-italics represent NHMRC & NRMMC (2004) drinking water guidelines for aesthetics

*** Nitrate NHMRC & NRMMC (2004) Australian Drinking Water Guideline Value is 50mg/L

0.00 Highlighted cells indicate exceedances of the ANZECC guideline standards

Table 4.3: Calga Monitoring and Production Bores – Six Monthly Laboratory Water Analysis Results (October 2010)

Bore		*Guideline Values for Freshwater Ecosystem Protection* or Drinking Water Quality***	CQ1	CQ3	CQ4	CQ5	CQ6	CQ7	CQ8	CQ9	CQ10	CQ11S	CQ11D	CQ12
Parameter	**Units**													
pH Value		6.5 – 8.5	4.38	5.8	5	4.31	4.99	4.53	4.34	4.41	4.45	4.5	5.49	4.27
Conductivity @ 25°C	µS/cm	-	150	123	100	160	165	102	163	117	163	160	149	146
Calcium	mg/L	-	<1	2	<1	4	3	<1	<1	<1	2	<1	1	<1
Magnesium	mg/L	-	3	4	1	4	9	2	5	2	3	5	4	5
Sodium	mg/L	180	12	11	12	11	9	12	15	13	17	14	16	11
Potassium	mg/L	-	<1	1	<1	2	2	<1	<1	<1	<1	4	1	<1
Hydroxide Alk as $CaCO_3$	mg/L	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alk as $CaCO_3$	mg/L	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alk as $CaCO_3$	mg/L	-	<1	16	4	<1	2	<1	<1	<1	<1	<1	10	<1
Sulphate	mg/L	250	16	3	8	29	9	2	3	2	22	37	26	29
Chloride	mg/L	250	18	19	17	18	20	20	19	24	26	15	16	15
Aluminium - Filtered	mg/L	*0.055*	0.49	0.02	0.1	1	0.49	0.16	0.64	0.2	1.17	0.97	0.06	0.96
Arsenic - Filtered	mg/L	*0.013*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium - Filtered	mg/L	*0.0002*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium - Filtered	mg/L	*ID*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001

Bore		***Guideline Values for Freshwater Ecosystem Protection* or Drinking Water Quality****	**CQ1**	**CQ3**	**CQ4**	**CQ5**	**CQ6**	**CQ7**	**CQ8**	**CQ9**	**CQ10**	**CQ11S**	**CQ11D**	**CQ12**
Parameter	**Units**													
Copper - Filtered	mg/L	*0.0014*	0.002	<0.001	0.002	<0.001	0.001	<0.001	0.001	<0.001	0.008	0.002	<0.001	<0.001
Lead - Filtered	mg/L	*0.0034*	0.001	0.002	0.003	<0.001	<0.001	<0.001	0.001	<0.001	0.014	0.02	0.013	<0.001
Manganese - Filtered	mg/L	*1.9*	0.006	1.24	0.003	0.006	0.008	0.001	0.002	0.001	0.047	0.007	0.032	<0.001
Nickel - Filtered	mg/L	*0.011*	0.003	0.012	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.005	0.001	0.002	<0.001
Selenium - Filtered	mg/L	*0.011*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc - Filtered	mg/L	*0.008*	0.018	0.017	0.025	0.009	0.03	<0.005	0.015	<0.005	0.087	0.074	0.092	<0.005
Boron - Filtered	mg/L	*0.37*	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron - Filtered	mg/L	*ID*	<0.05	4.4	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.29	<0.05	<0.05	<0.05
Mercury - Filtered	mg/L	*0.0006*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride as F	mg/L	-	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite as N	mg/L	3	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N***	mg/L	*0.7*	1.14	<0.01	0.3	1.43	7.92	1.52	9.22	0.99	1.52	0.14	0.03	0.54

* *Italics represent ANZECC (2000) 95 percentile standards for Freshwater Ecosystems*

** Non-italics represent NHMRC & NRMMC (2004) drinking water guidelines for aesthetics

*** Nitrate NHMRC & NRMMC (2004) Australian Drinking Water Guideline Value is 50mg/L

0.00 Highlighted cells indicate exceedances of the ANZECC guideline standards

Bore		*Guideline Values for Freshwater Ecosystem Protection* or Drinking Water Quality***	CQ13	CP3	CP4	CP5	CP6	CP7	CP8	MW7	MW8	MW9	MW10	MW13	MW16
Parameter	**Units**														
pH Value		6.5 – 8.5	5.02	4.6	4.49	4.33	4.25	4.65	4.33	4.38	4.68	4.5	4.33	4.64	4.55
Conductivity @ 25°C	µS/cm	-	192	156	216	250	212	172	157	122	89	92	142	111	122
Calcium	mg/L	-	<1	<1	1	2	<1	8	<1	<1	<1	<1	<1	<1	<1
Magnesium	mg/L	-	6	3	6	15	11	5	3	2	2	1	2	2	2
Sodium	mg/L	180	22	17	24	13	16	6	18	14	11	11	14	13	15
Potassium	mg/L	-	<1	2	2	2	<1	11	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alk as $CaCO_3$	mg/L	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alk as $CaCO_3$	mg/L	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alk as $CaCO_3$	mg/L	-	2	2	2	<1	<1	<1	<1	<1	2	<1	<1	<1	3
Sulphate	mg/L	250	1	27	6	1	2	19	6	3	4	3	5	3	2
Chloride	mg/L	250	32	19	33	22	24	11	29	27	19	20	30	25	28
Aluminium	mg/L	*0.055*	0.43	0.55	0.24	1.01	1.04	0.34	0.69	0.27	0.26	0.4	0.92	0.1	0.22
Arsenic	mg/L	*0.013*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	*0.0002*	0.0001	<0.0001	0.0005	0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	*ID*	0.003	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001

Bore		Guideline Values for Freshwater Ecosystem Protection* or Drinking Water Quality**	CQ13	CP3	CP4	CP5	CP6	CP7	CP8	MW7	MW8	MW9	MW10	MW13	MW16
Parameter	**Units**														
Copper	mg/L	*0.0014*	0.004	0.164	0.019	0.324	0.011	<0.001	<0.001	<0.001	0.001	<0.001	0.003	0.003	0.001
Lead	mg/L	*0.0034*	0.045	0.012	0.005	0.012	0.002	<0.001	0.001	<0.001	0.002	0.001	0.005	0.004	0.001
Manganese - Filtered	mg/L	*1.9*	0.024	0.002	0.09	0.004	0.002	0.02	0.002	0.005	0.004	0.004	0.012	0.055	0.01
Nickel - Filtered	mg/L	*0.011*	0.003	<0.001	0.221	0.014	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.003	0.001
Selenium - Filtered	mg/L	*0.011*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc - Filtered	mg/L	*0.008*	0.125	0.094	2.2	1.26	0.055	0.037	<0.005	0.006	0.02	0.01	0.06	0.087	0.018
Boron - Filtered	mg/L	*0.37*	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron - Filtered	mg/L	*ID*	0.18	0.11	0.23	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	<0.05
Mercury - Filtered	mg/L	*0.0006*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride as F	mg/L	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
Nitrite as N	mg/L	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	*0.7*	9.26	0.87	10.2	20	14.3	9.98	2.37	0.09	0.1	0.24	0.36	0.52	0.14

* *Italics represent ANZECC (2000) 95 percentile standards for Freshwater Ecosystems*

** Non-italics represent NHMRC & NRMMC (2004) drinking water guidelines for aesthetics

*** Nitrate NHMRC & NRMMC (2004) Australian Drinking Water Guideline Value is 50mg/L

0.00 Highlighted cells indicate exceedances of the ANZECC guideline standards

Table 4.3: Dissolved Metals – Exceedances of ANZECC (2000) Freshwater Ecosystem Guidelines for 2010

Dissolved Metal	ANZECC (2000) Freshwater Ecosystem Protection Guideline	Reported range (mg/L)	Exceedances
Aluminium	0.055 mg/L	0.02 – 1.87	All except CQ3 (Oct)
Arsenic	0.013 mg/L	<0.001	None
Boron	0.09 mg/L	<0.05-0.06	None except CP3 (Oct)
Cadmium	0.0002 mg/L	<0.0001-0.0005	CQ6 (Apr), CP5 and CP6 (Oct)
Chromium	0.001 mg/L	<0.001 – 0.004	CQ1, CQ10, MW7, MW8 (Apr)- CQ13, CP4, MW9 (Oct)
Copper	0.0014 mg/L	<0.001-0.324	All except CQ5, CQ7, CQ11D, MW7, MW9 (April), CQ3, CQ5-9, CQ11D, CQ12, CP7-8, MW7-9, MW16 (Oct)
Iron	-	<0.05-4.4	N/A
Lead	0.0034 mg/L	<0.001-0.056	CP3, CQ4, CQ6, CQ10-14, MW8, MW10, MW13 (Apr), CP3-5,CQ10-13, MW10, MW13 (Oct)
Manganese	1.9 mg/L	<0.001-1.31	None
Mercury	0.00006 mg/L	<0.0001-0.0004	None except CP8 (Apr)
Nickel	0.011 mg/L	<0.001-0.221	CQ3, CP4, CP5 (Oct)
Selenium	0.011 mg/L	<0.01	None
Zinc	0.008 mg/L	0.006-2.2	All except CP5, MW9 (Apr), MW7 (Oct)

Table 4.4: Dissolved Metals – Trends in Exceedances of ANZECC (2000) Freshwater Ecosystem Guidelines

	Aluminium	Arsenic	Cadmium	Chromium	Copper	Lead	Manganese	Nickel	Selenium	Zinc	Boron	Iron	Mercury
Oct-06	20	0	0	0	14	15	0	1	0	23	0	0	0
Apr-07	22	0	0	0	5	11	0	1	0	24	0	0	0
Oct-07	24	0	3	2	14	10	0	0	0	22	0	0	1
Apr-08	24	0	2	2	22	18	0	1	0	24	0	0	0
Oct-08	21	0	1	1	13	12	0	2	0	22	0	0	0
Apr-09	24	0	0	0	22	11	0	1	0	23	0	0	0
Oct -09	22	0	1	1	15	9	0	1	0	21	0	0	0
Apr-10	24	0	1	4	19	12	0	0	0	22	0	0	1
Oct -10	24	0	2	3	13	10	0	3	0	24	1	0	0

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This audit has shown that the groundwater regime at Calga Quarry and the surrounding monitoring network is trending in a similar and/or more stable manner to that observed in previous reporting periods. During the 2010 year, groundwater levels across the Rocla premises, and in the private bores and associated monitoring bores, followed similar natural recharge/discharge patterns as those observed in the previous years. This correlation between rainfall recharge and groundwater levels has been identified in all previous reporting periods.

Because of the clear correlation of water level fluctuations with rainfall events, it is concluded that the observed trends can be entirely attributed to natural responses to climatic variation, and there was no evidence in the 2010 data of impact from the quarry activities. Monitoring records continued to show that there has been no drawdown of water levels due to sand extraction outside the quarry site in 2010, or at any of the neighbouring private production bores.

Water quality records for 2009 showed that recharge from higher than average rainfall for the first half of 2009 generally led to a freshening of the groundwater aquifer. These trends have been maintained during 2010, albeit with lesser rainfall and therefore reduced dilution.

Elevated nitrates continue to be reported in some of the private water supply bores and the adjacent monitoring bores, but background concentrations continue to be very low.

Apart from nitrate, water quality monitoring did not reveal any trends that were not consistent with background fluctuations and climate related trends, and showed that there were no impacts on the groundwater aquifer from quarry activities.

In terms of compliance, a summary of our findings is as follows:

> *The analysis of groundwater levels and groundwater quality clearly show that the quarry activities during 2010 were in compliance with the groundwater impact assessment criteria, as detailed in the approved 2006 Site Water Management Plan.*

5.2 Recommendations

Due to the lack of any trend in the number of exceedances of metals and nitrates, it is recommended that sampling and laboratory analysis of water quality be reduced to an annual monitoring round. Given the lack of any exceedances of the ANZECC (2000) guideline values for arsenic, manganese, selenium and boron throughout the monitoring period, it is recommended that these parameters be removed from the analytical suite of tests.

6. REFERENCES

ANZECC, 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, by Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ)*, dated October 2000.

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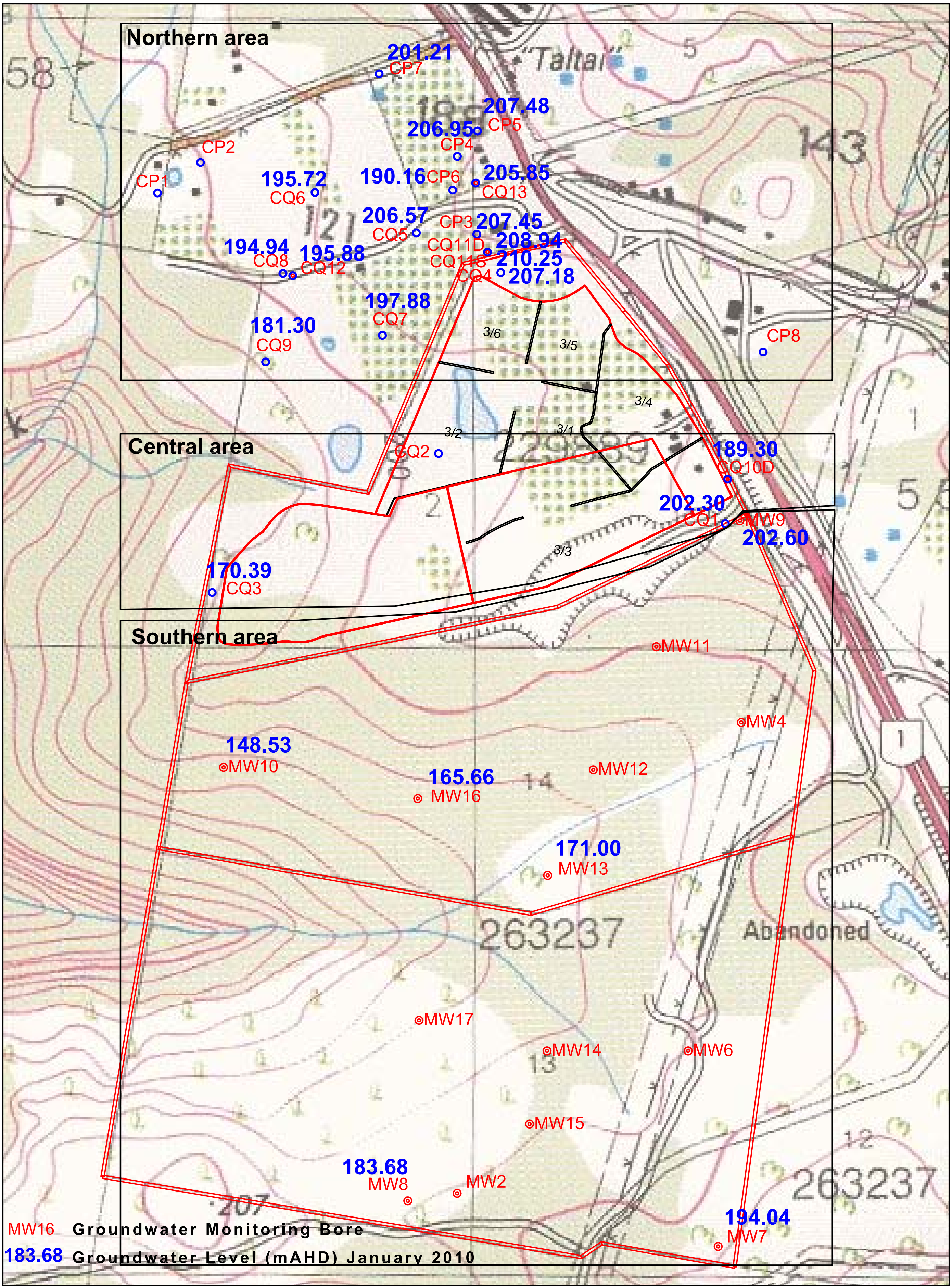
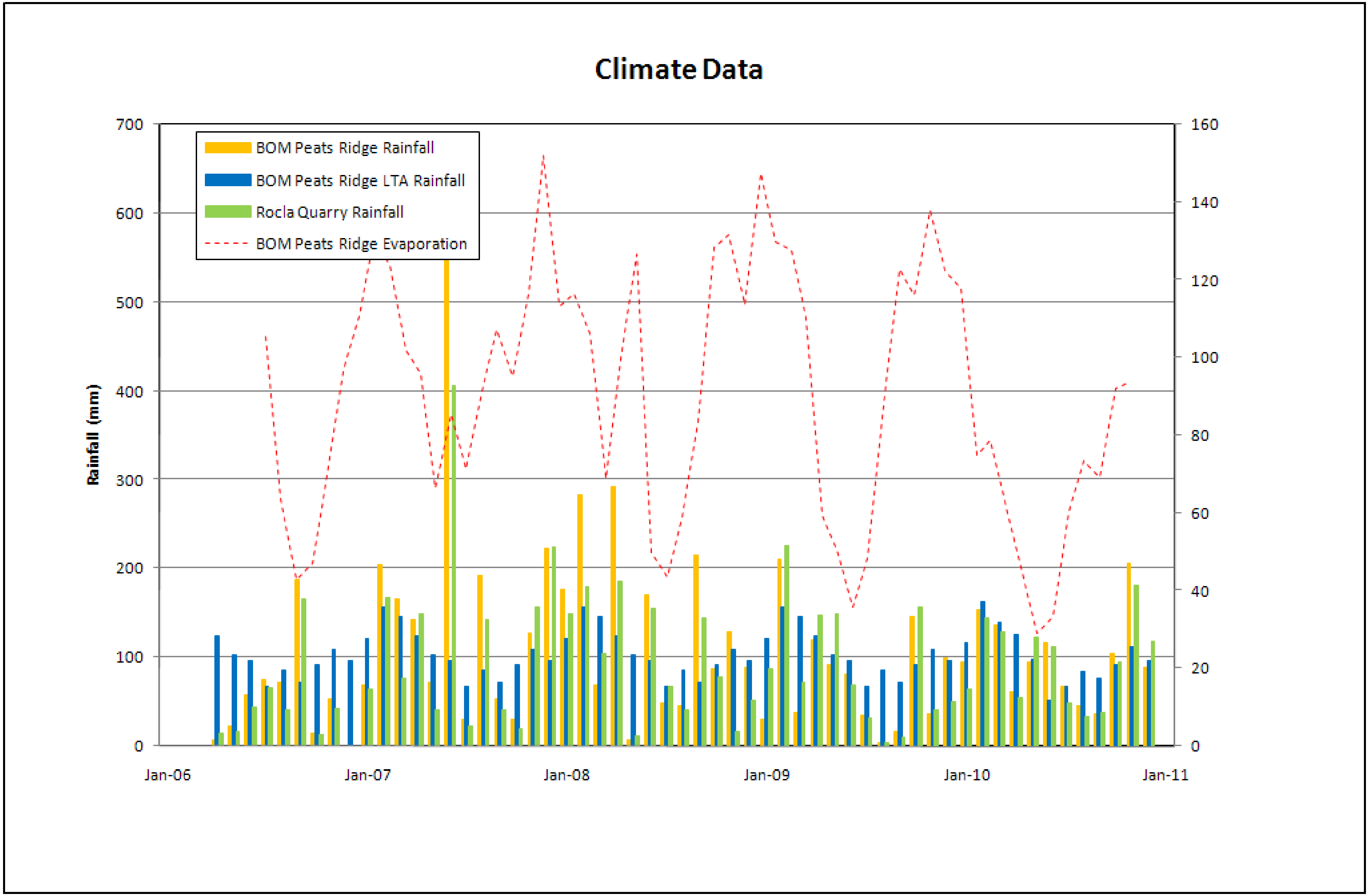
Peter Dundon and Associates Pty Ltd, 2007. *Calga Sand Quarry, Annual Groundwater Performance Review*.

R W Corkery & Co Pty Limited, 2006. *Site Water Management Plan for the Calga Sand Quarry,* dated February 2006.

FIGURES



DATE: 16 April 2011	SCALE: 1:20 000	**Rocla Materials Pty Ltd**	
AUTHOR: HZ CHECKED: CS	PROJECT NO: S04-B7	CALGA SAND QUARRY GROUNDWATER BORE LOCATION PLAN	
DRAWING NO: S04-001d	REVISION: D		
RPS Aquaterra			Figure 1



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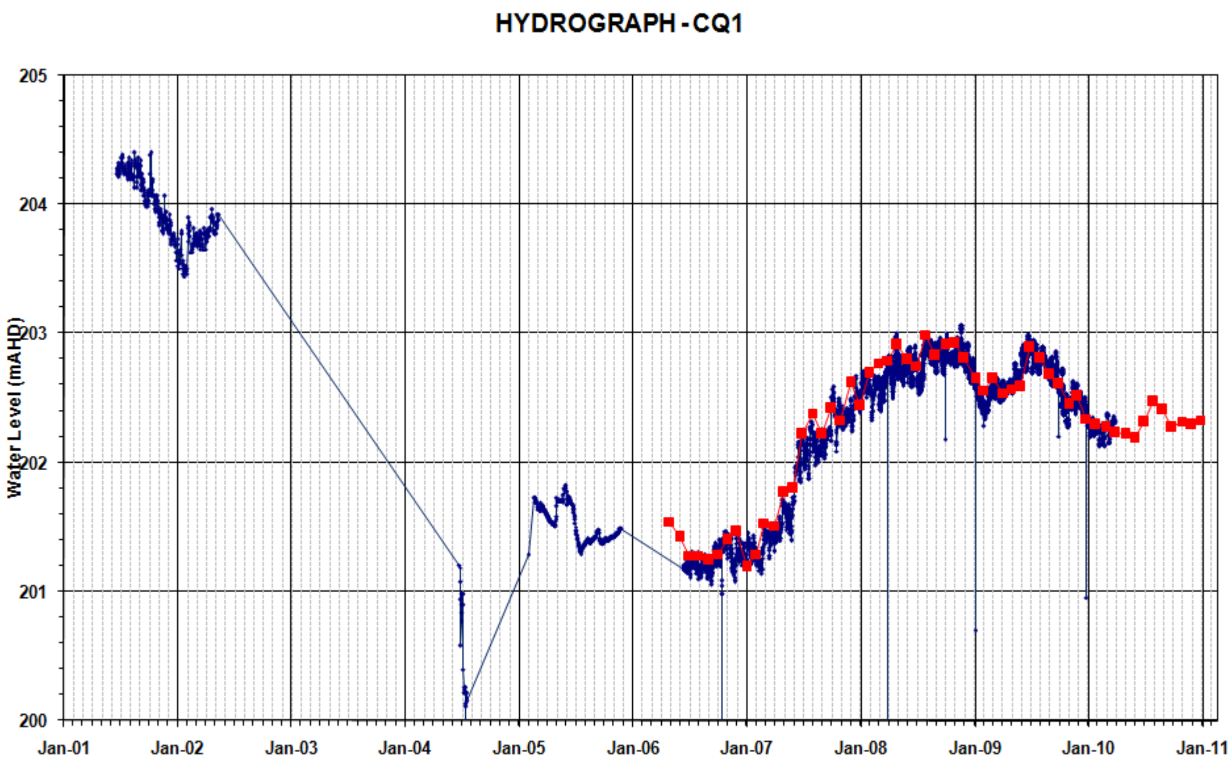
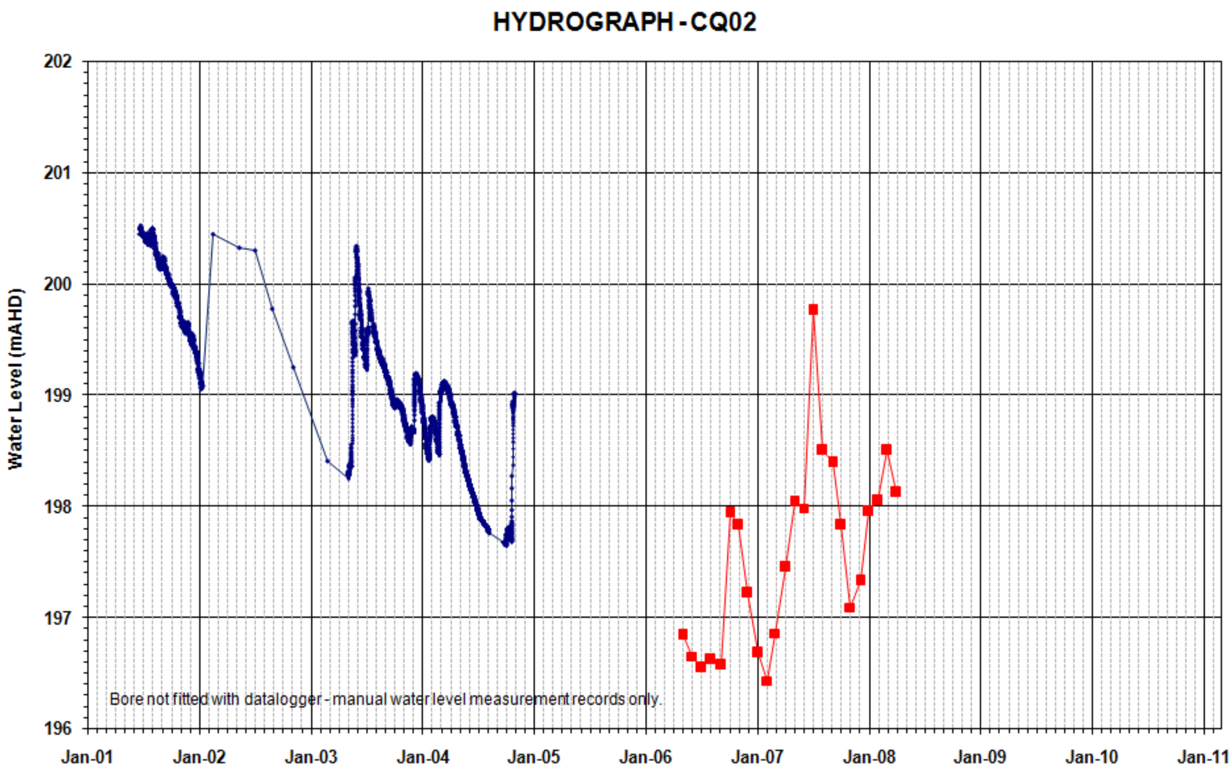
Climate Data FIGURE 2





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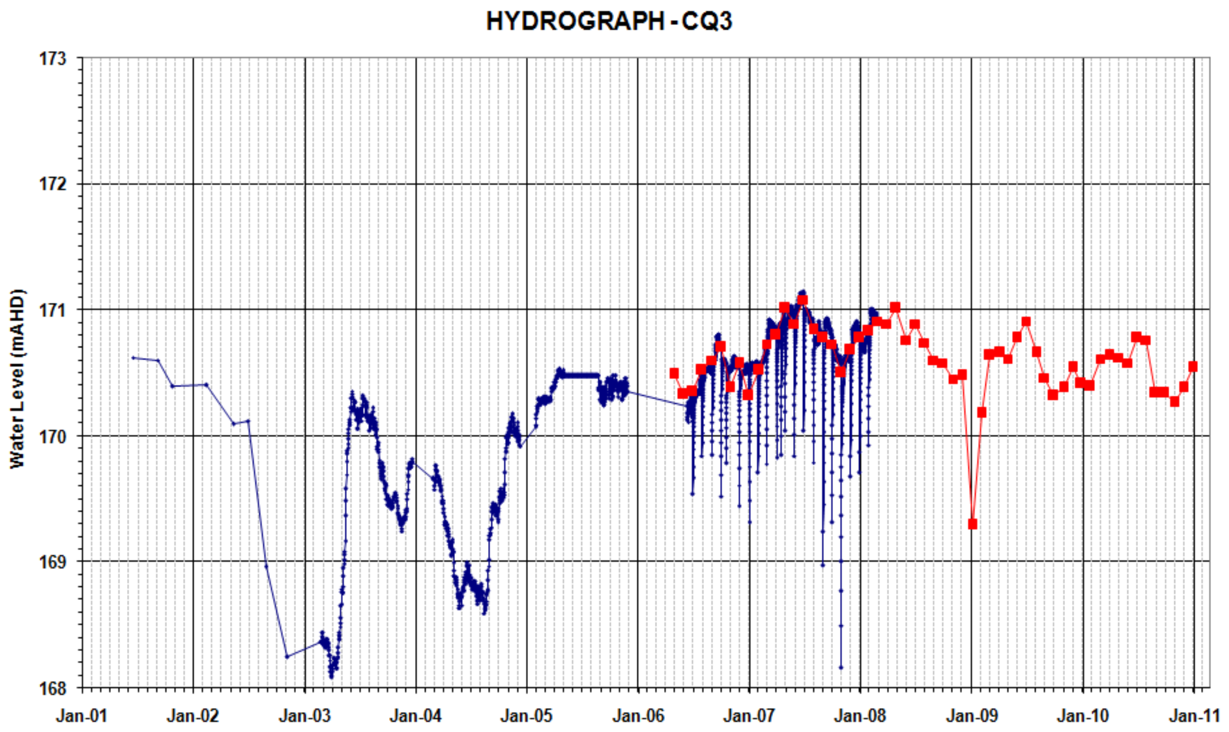
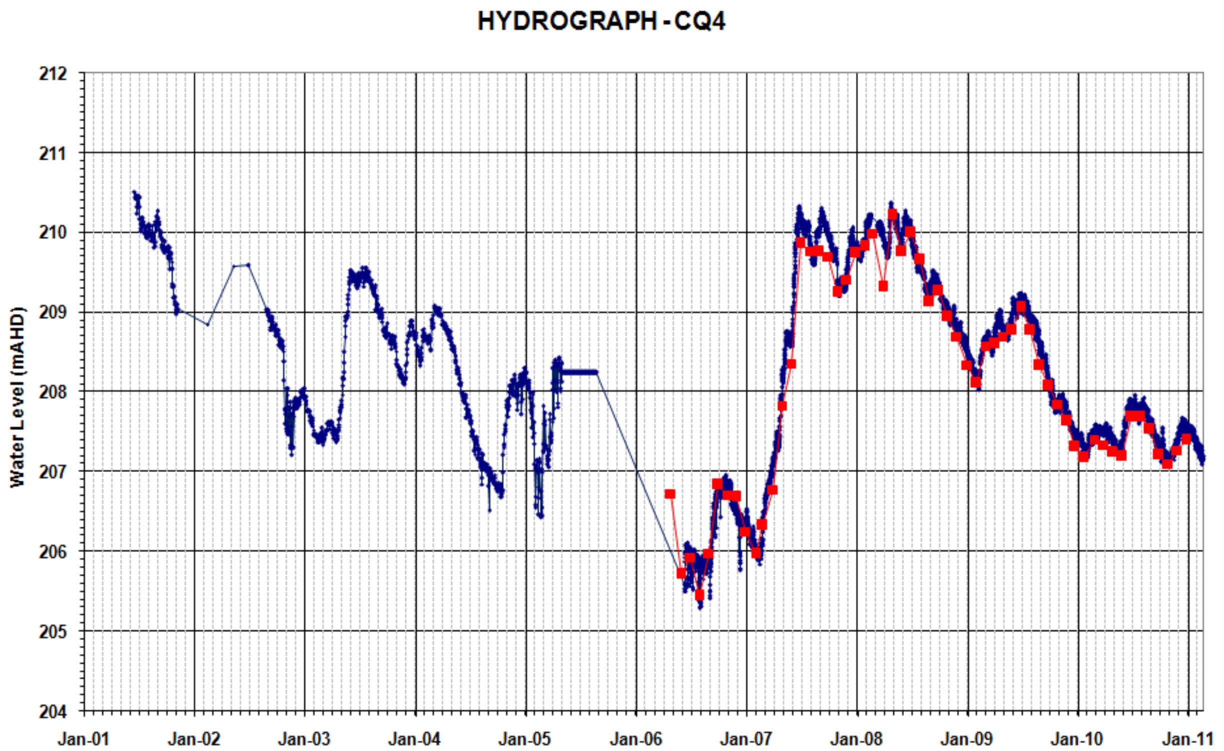
Hydrographs CQ1 and CQ2 FIGURE 3





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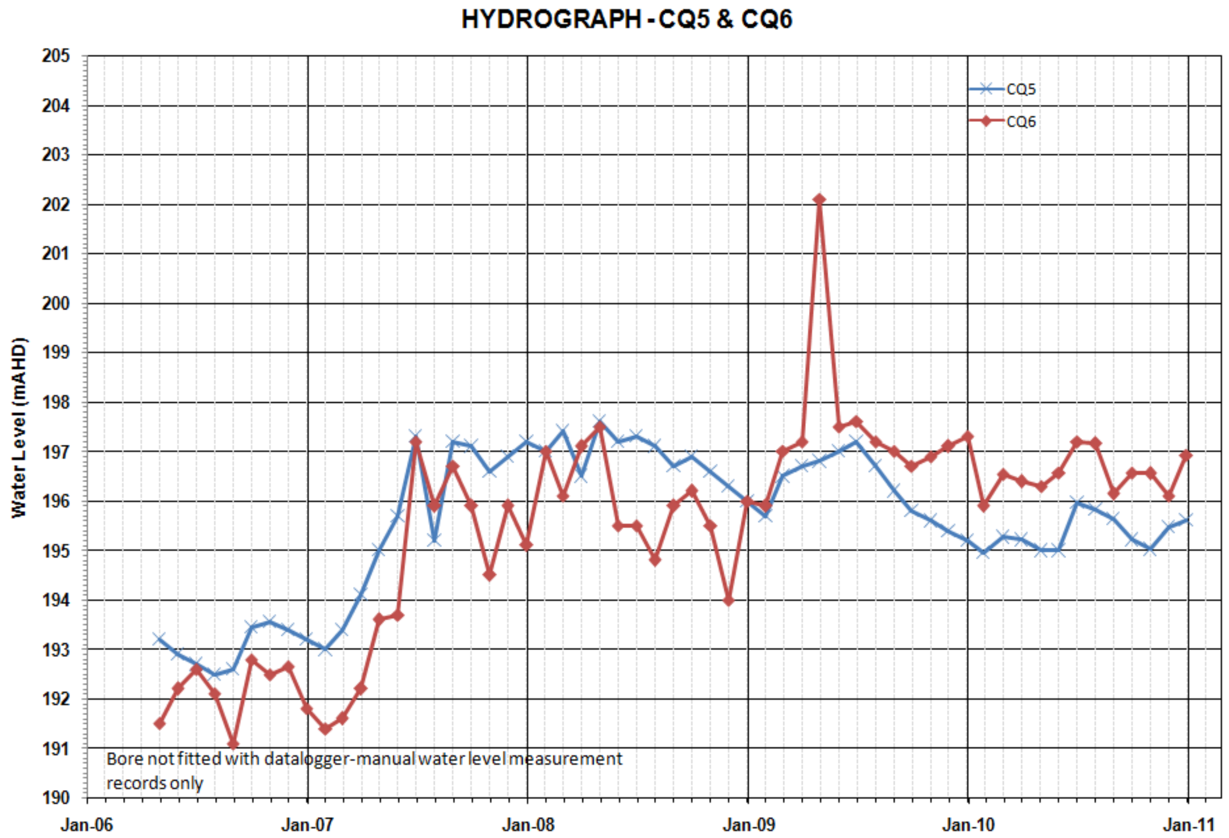
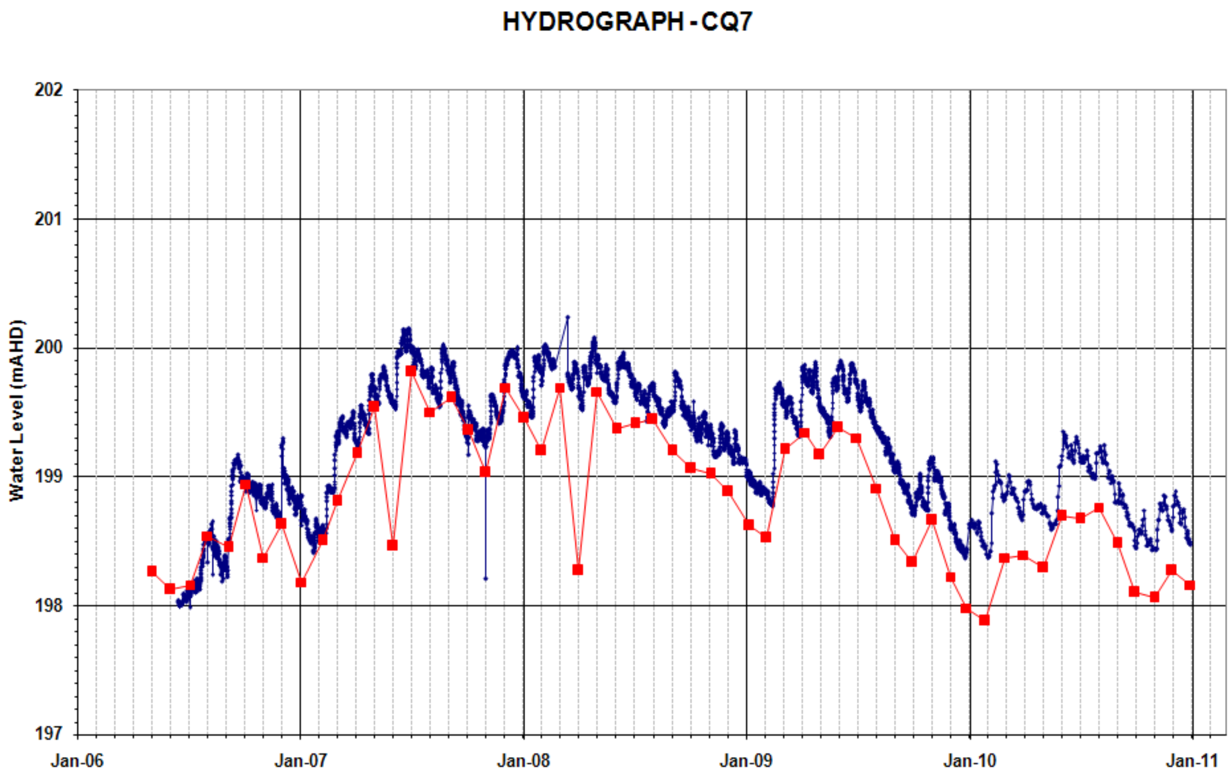
Hydrographs CQ3 and CQ4 FIGURE 4





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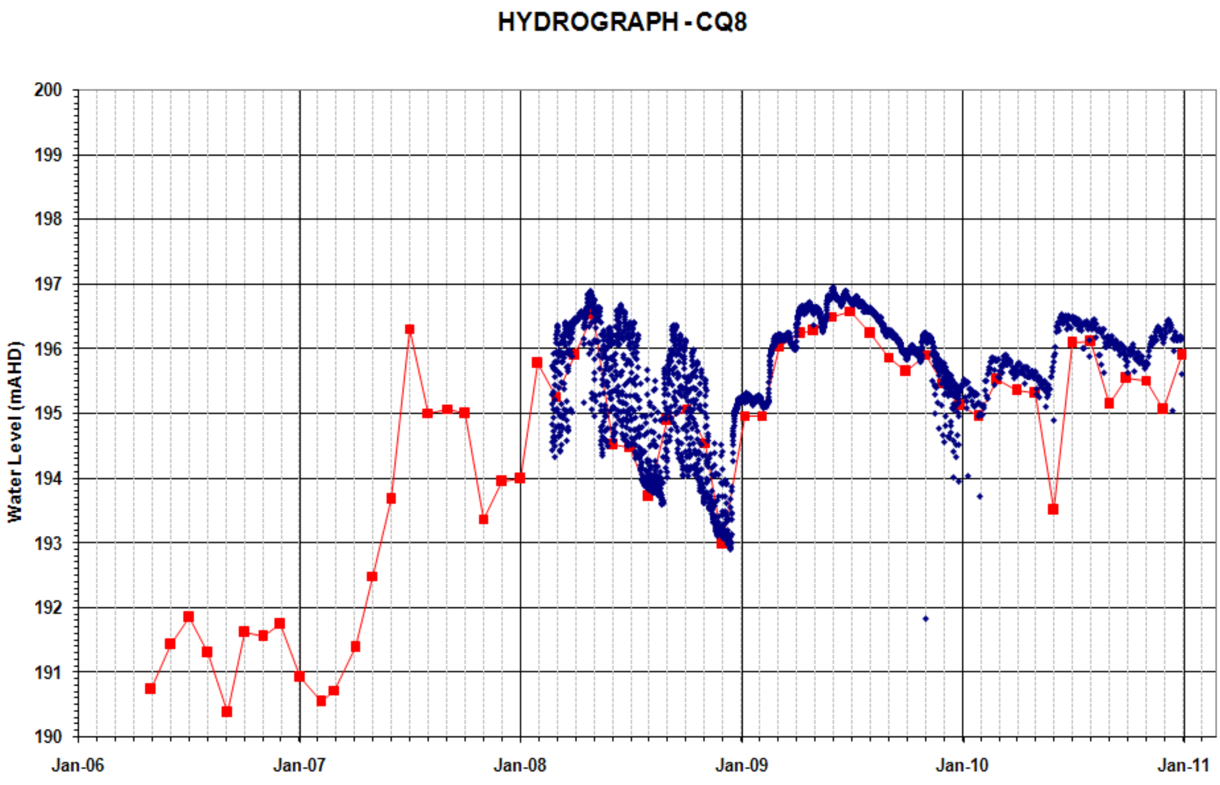
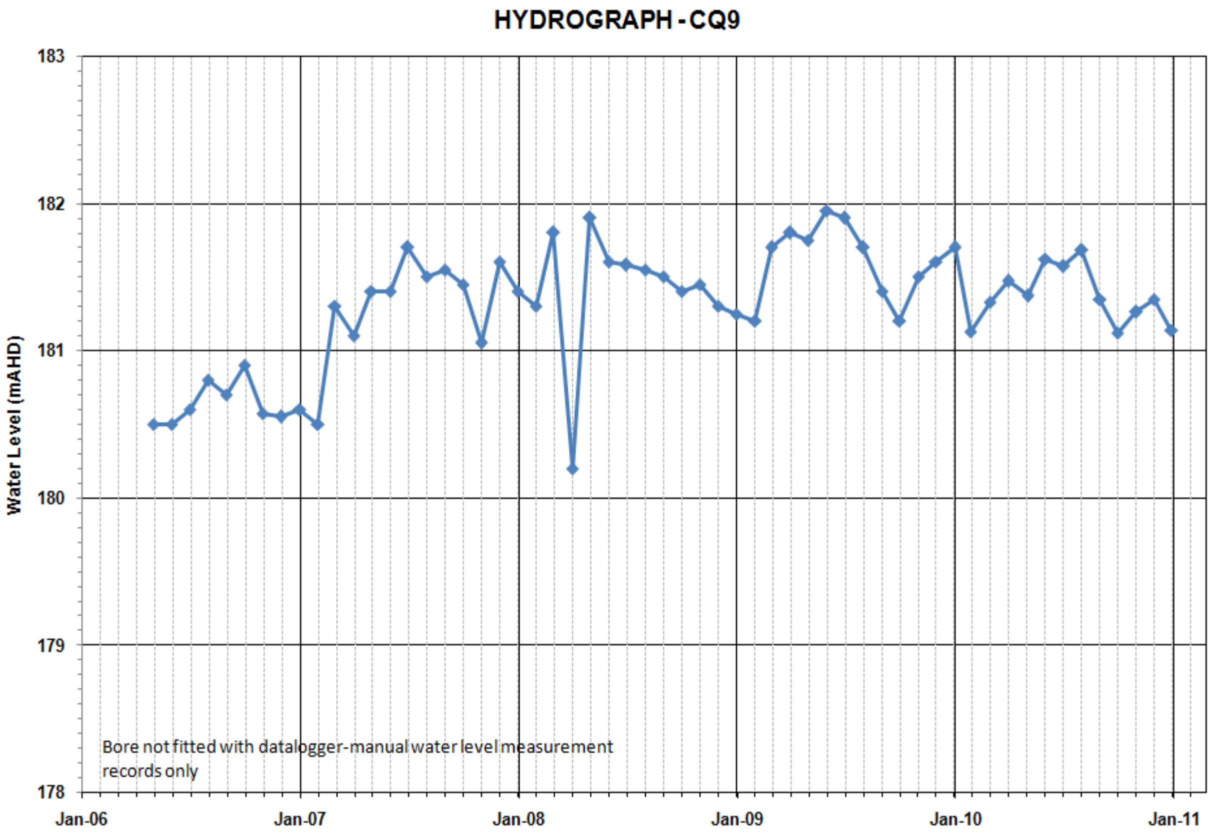
Hydrographs CQ5,CQ6 and CQ7 FIGURE 5





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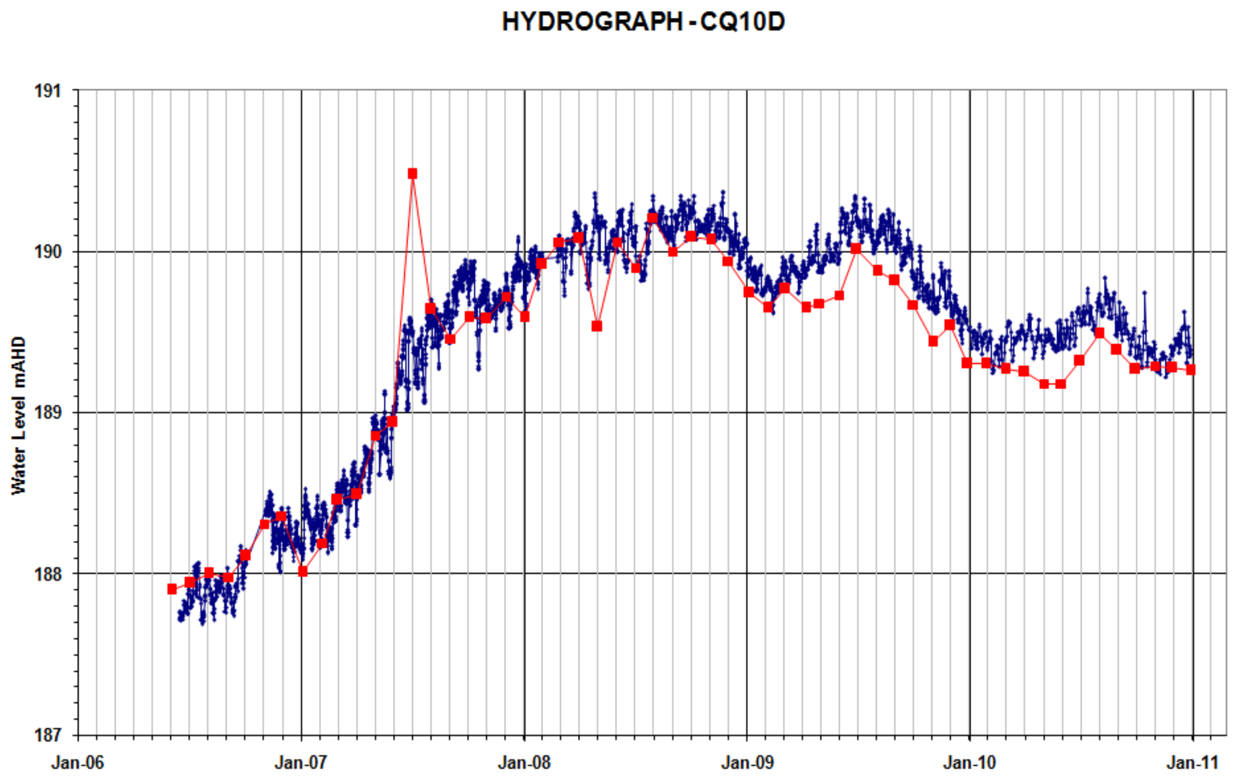
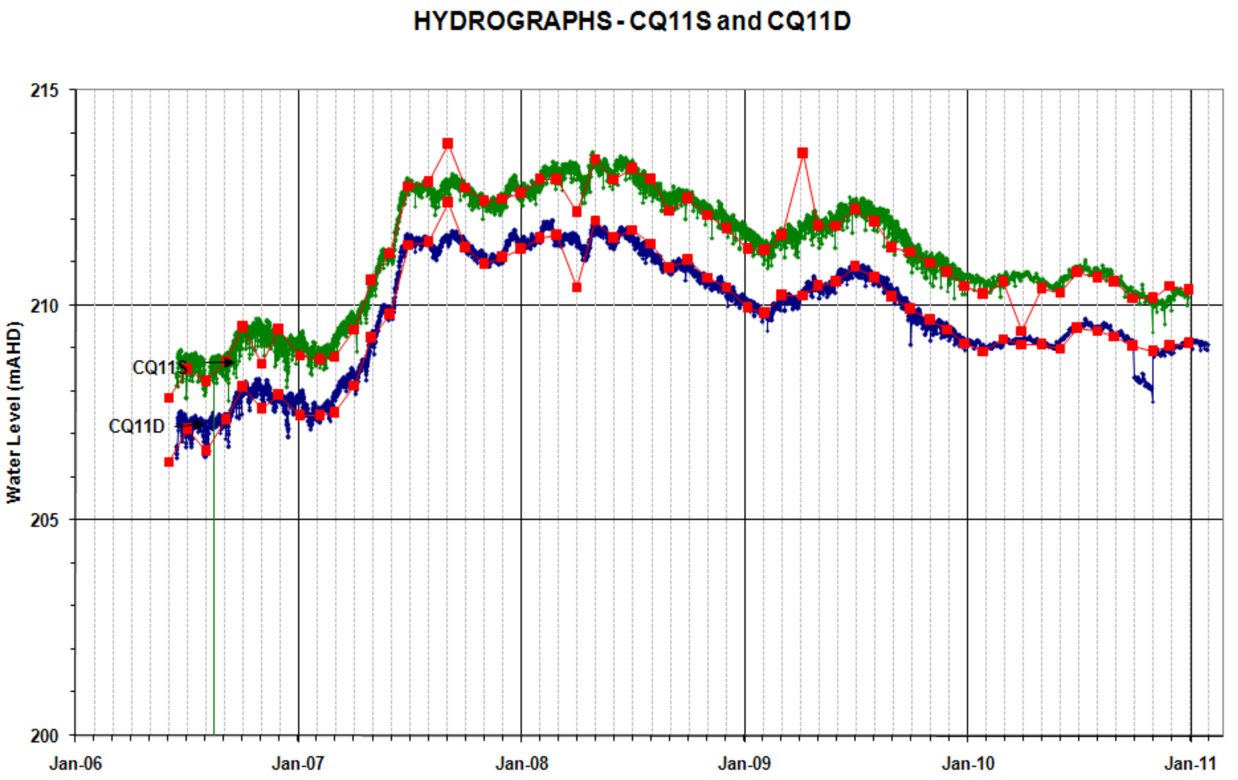
Hydrographs CQ8 and CQ9 FIGURE 6





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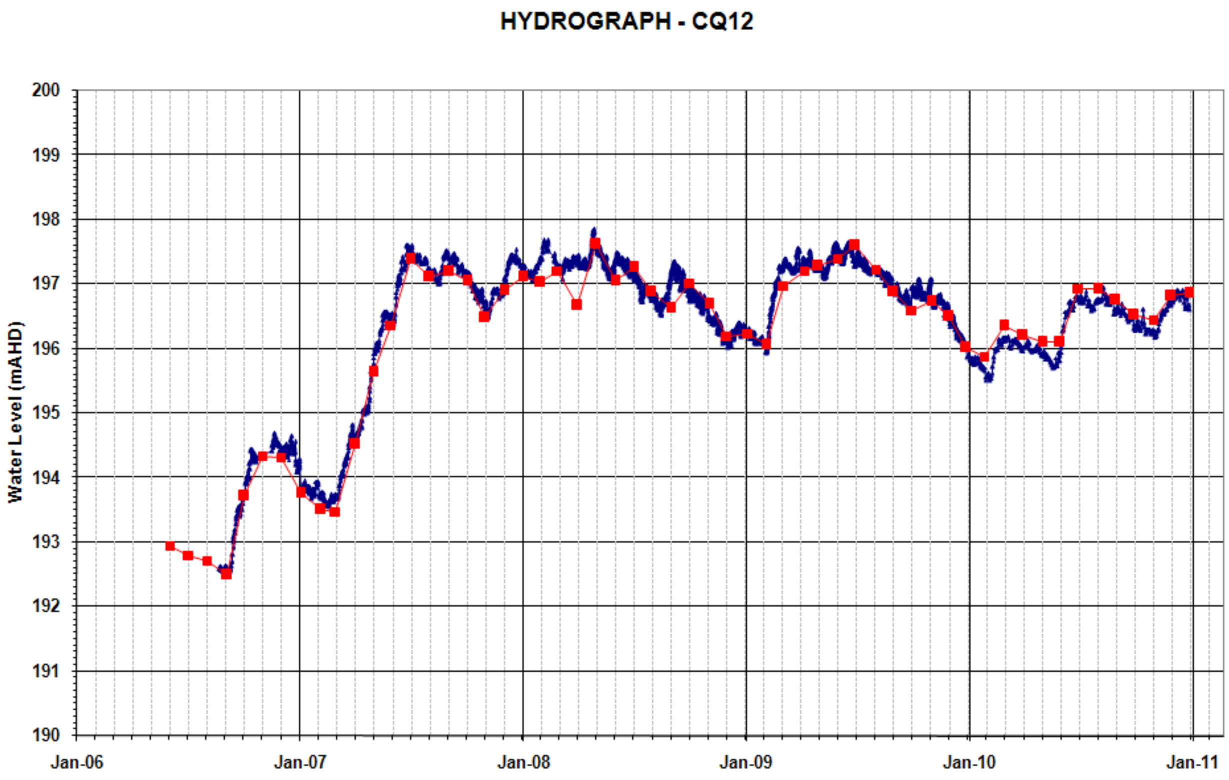
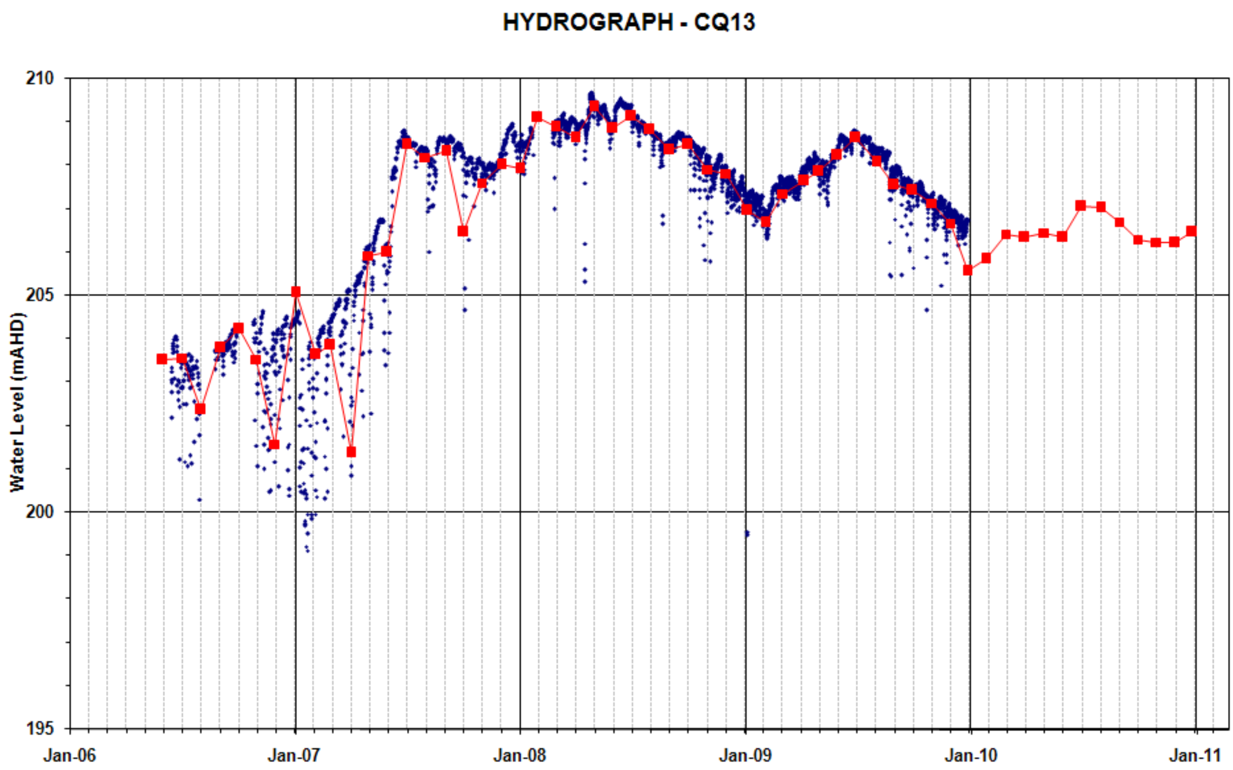
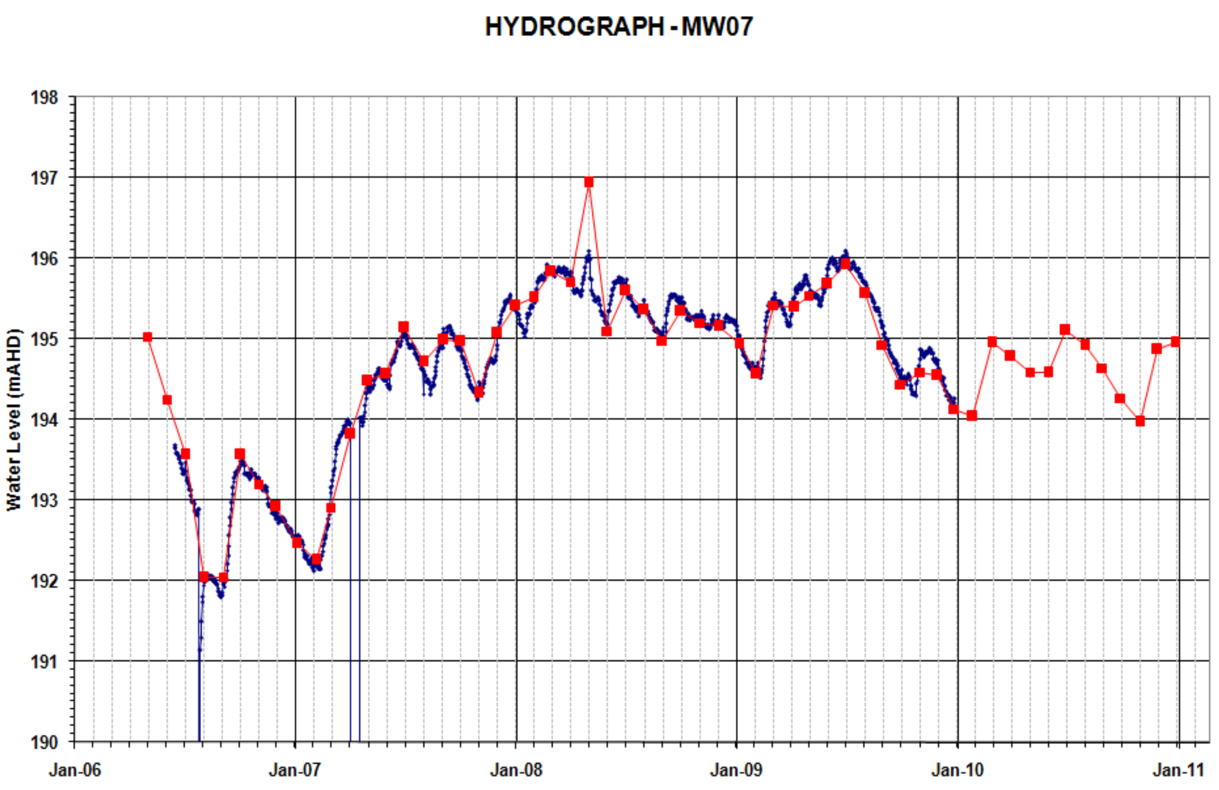
Hydrographs CQ10,CQ11S and CQ11D FIGURE 7

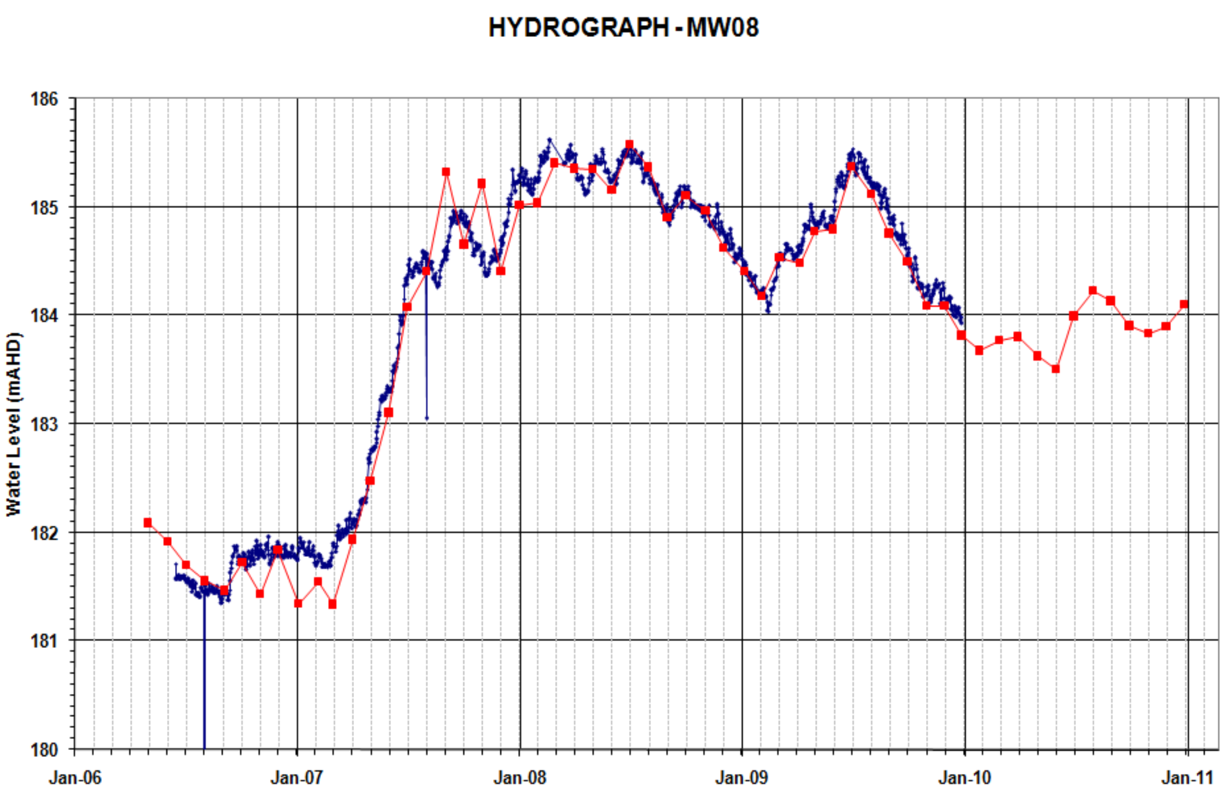


HYDROGRAPH - CQ12
Water Level (mAHD)
200
199
198
197
196
195
194
193
192
191
190
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11



HYDROGRAPH - CQ13
Water Level (mAHD)
210
205
200
195
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11





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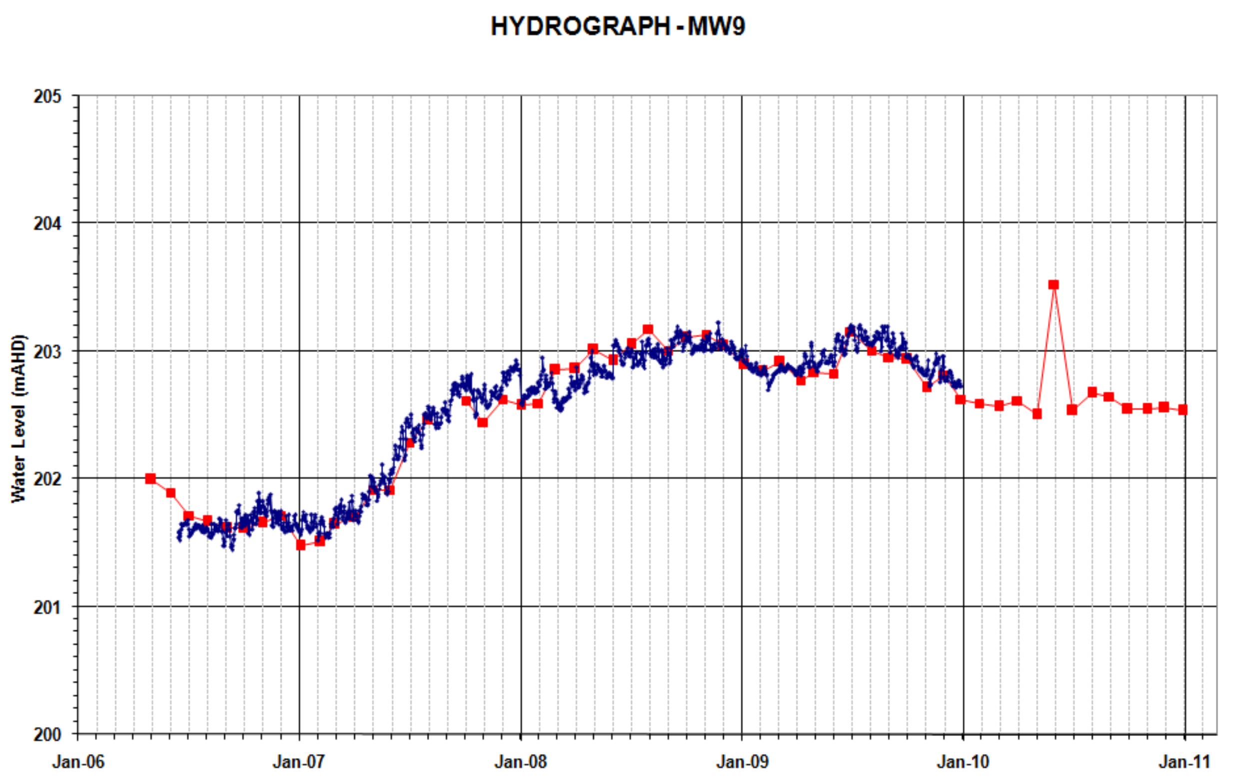
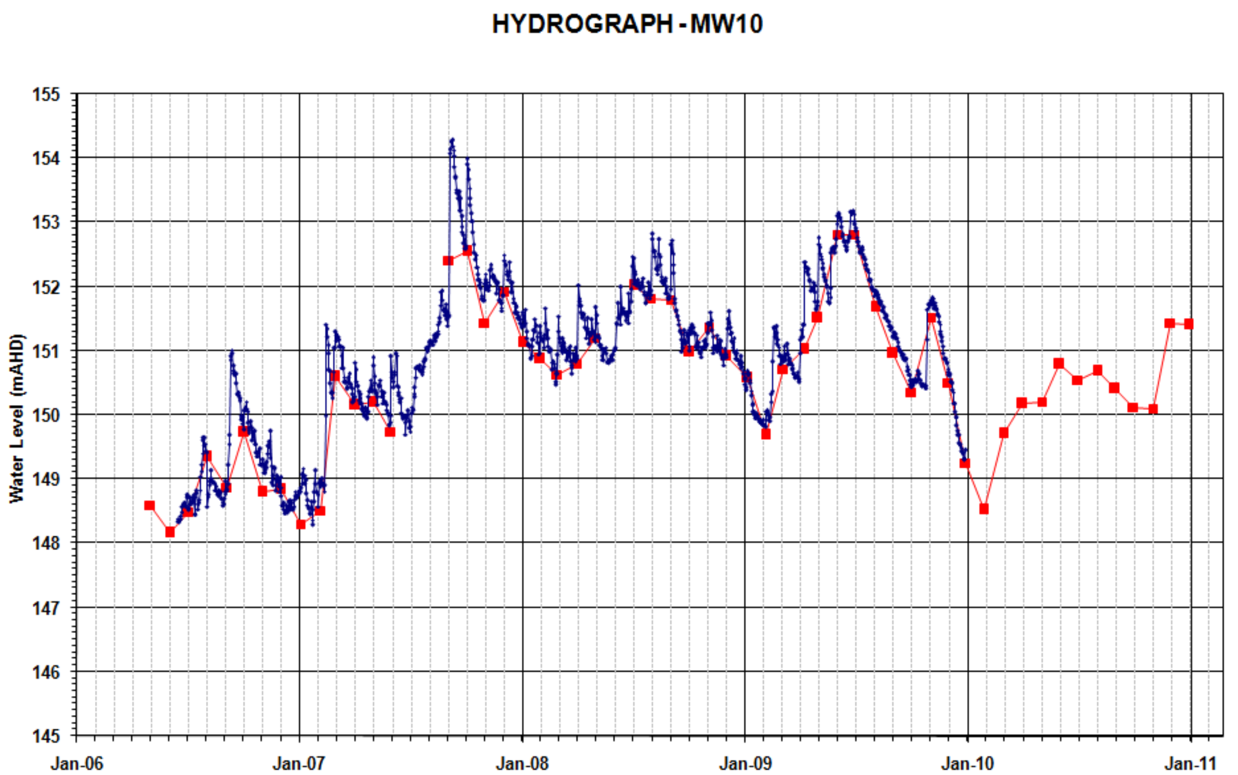
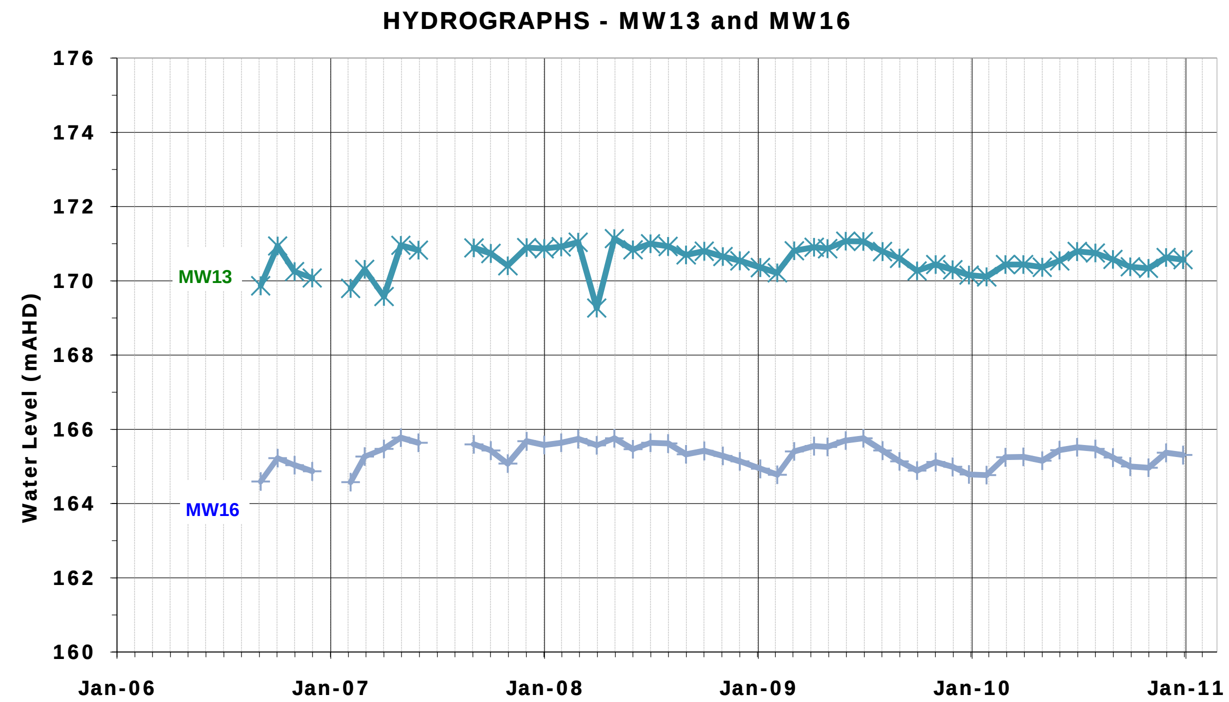
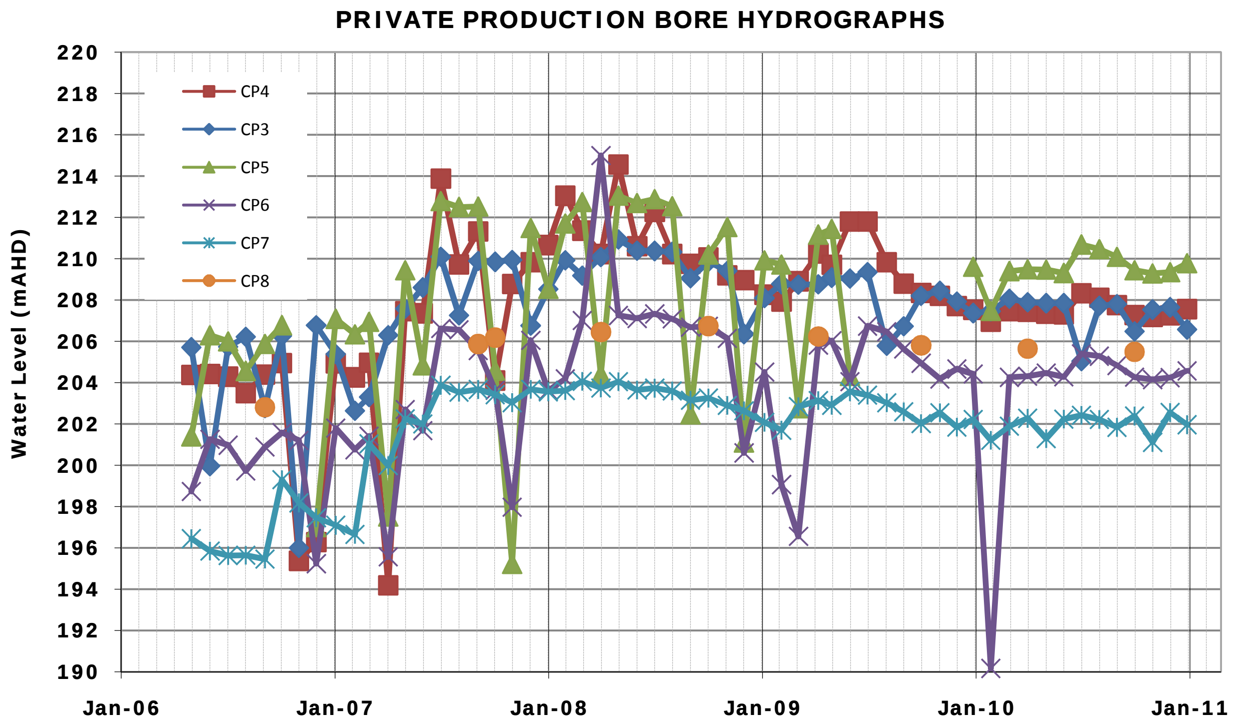
Hydrographs WM07, WM08 FIGURE 9





Hydrographs WM9, WM10 FIGURE 10





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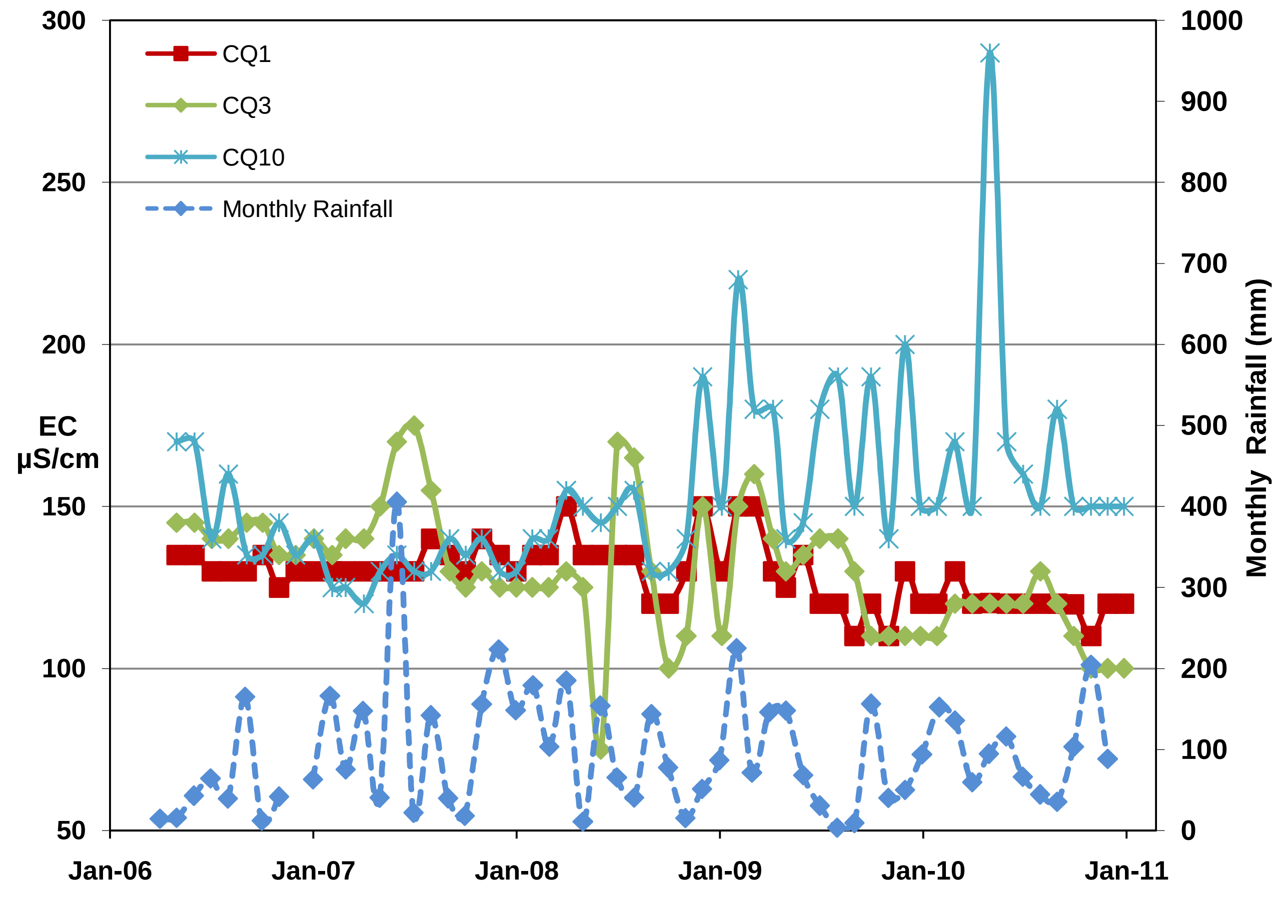
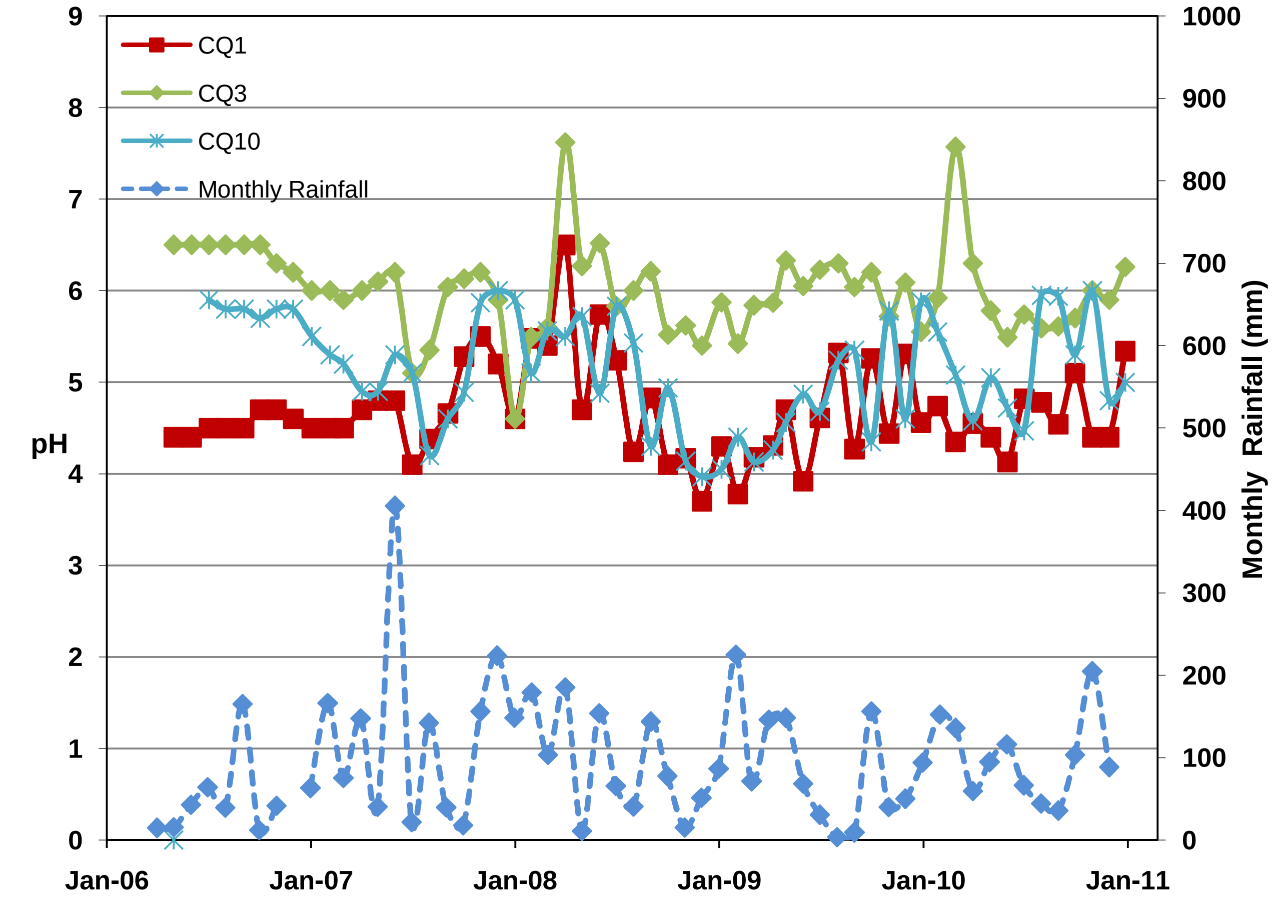
Hydrographs MW13, MW16 and Private Production Bores FIGURE 11





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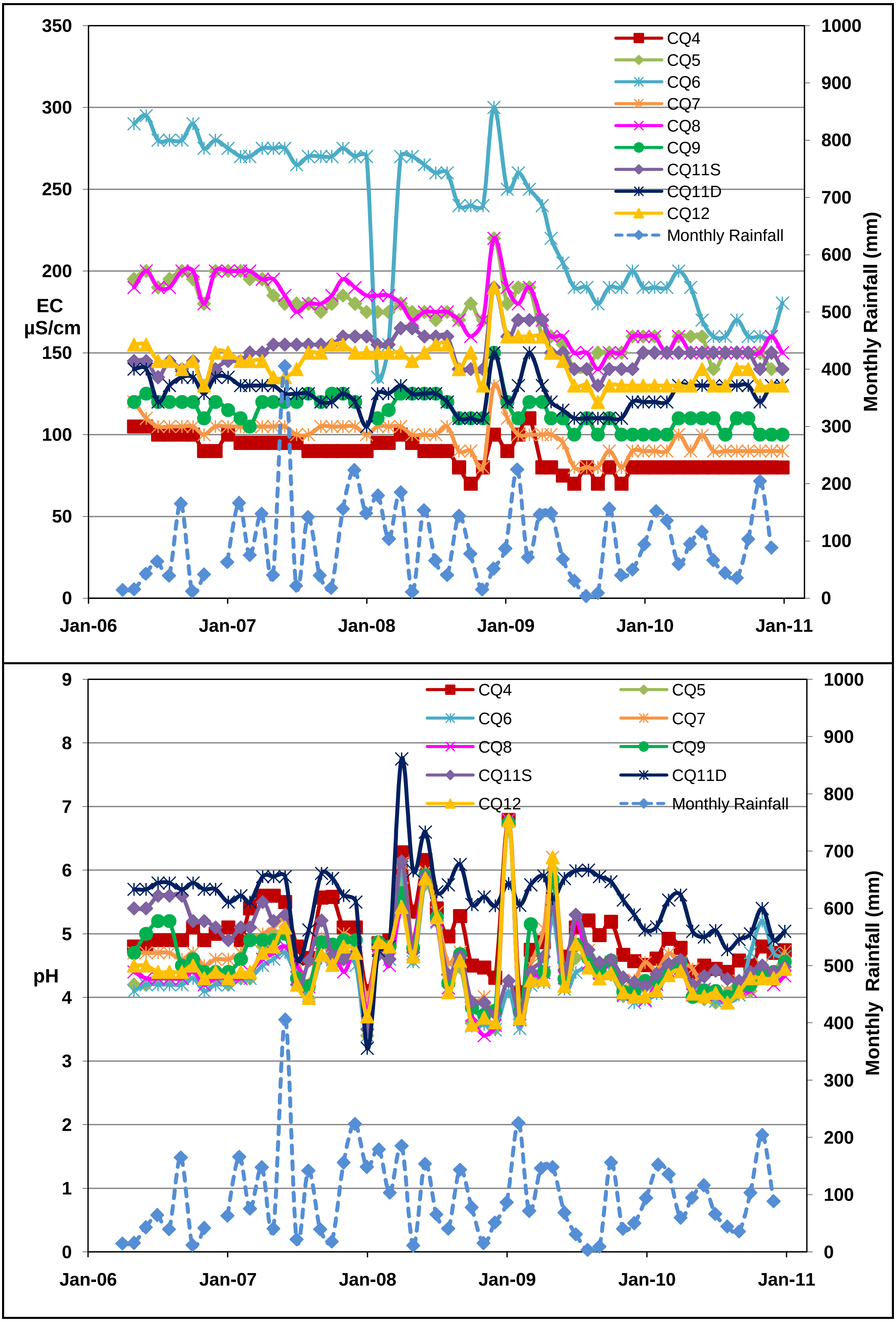
CQ1, CQ3 and CQ10 EC and PH FIGURE 12



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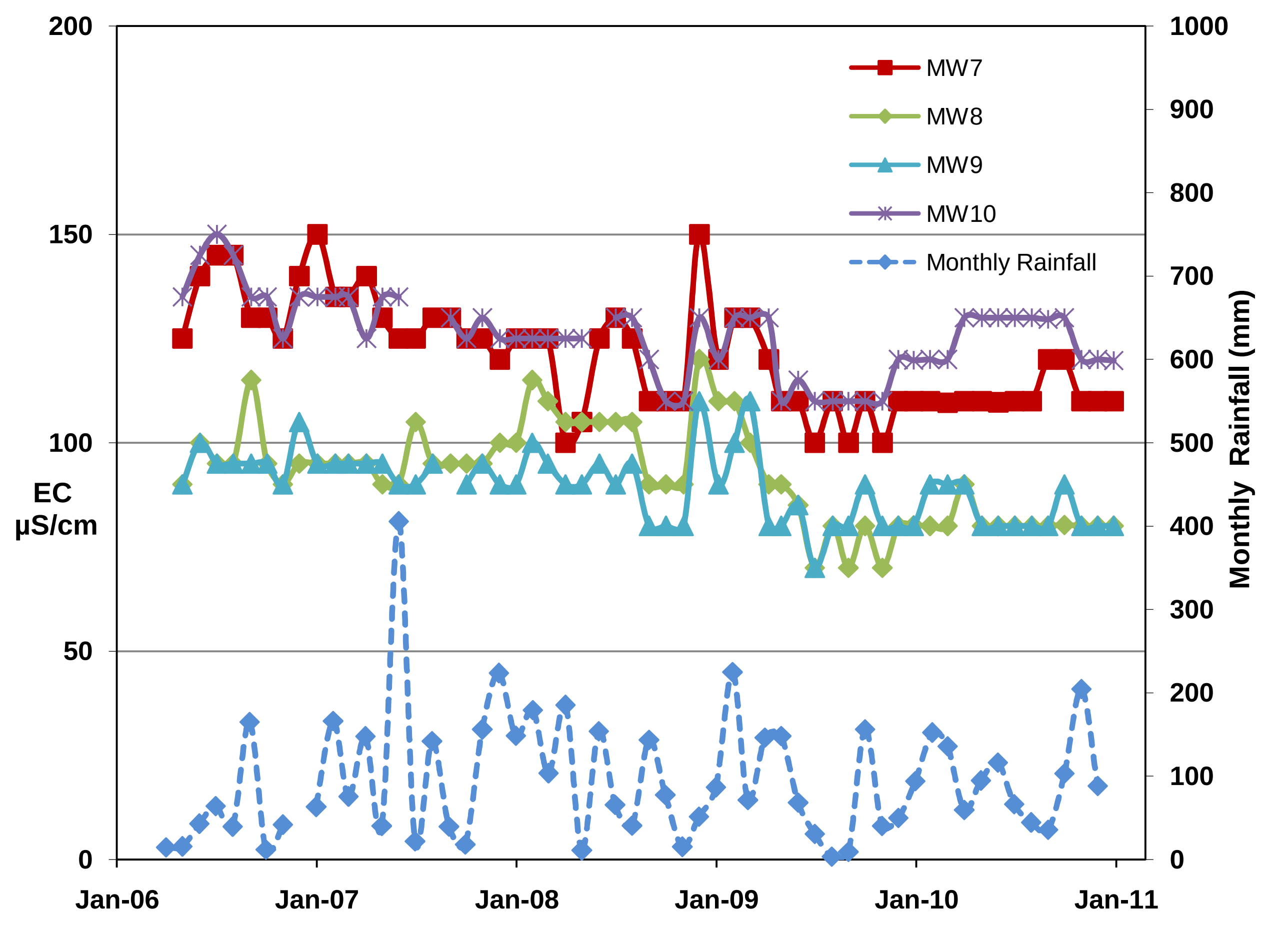
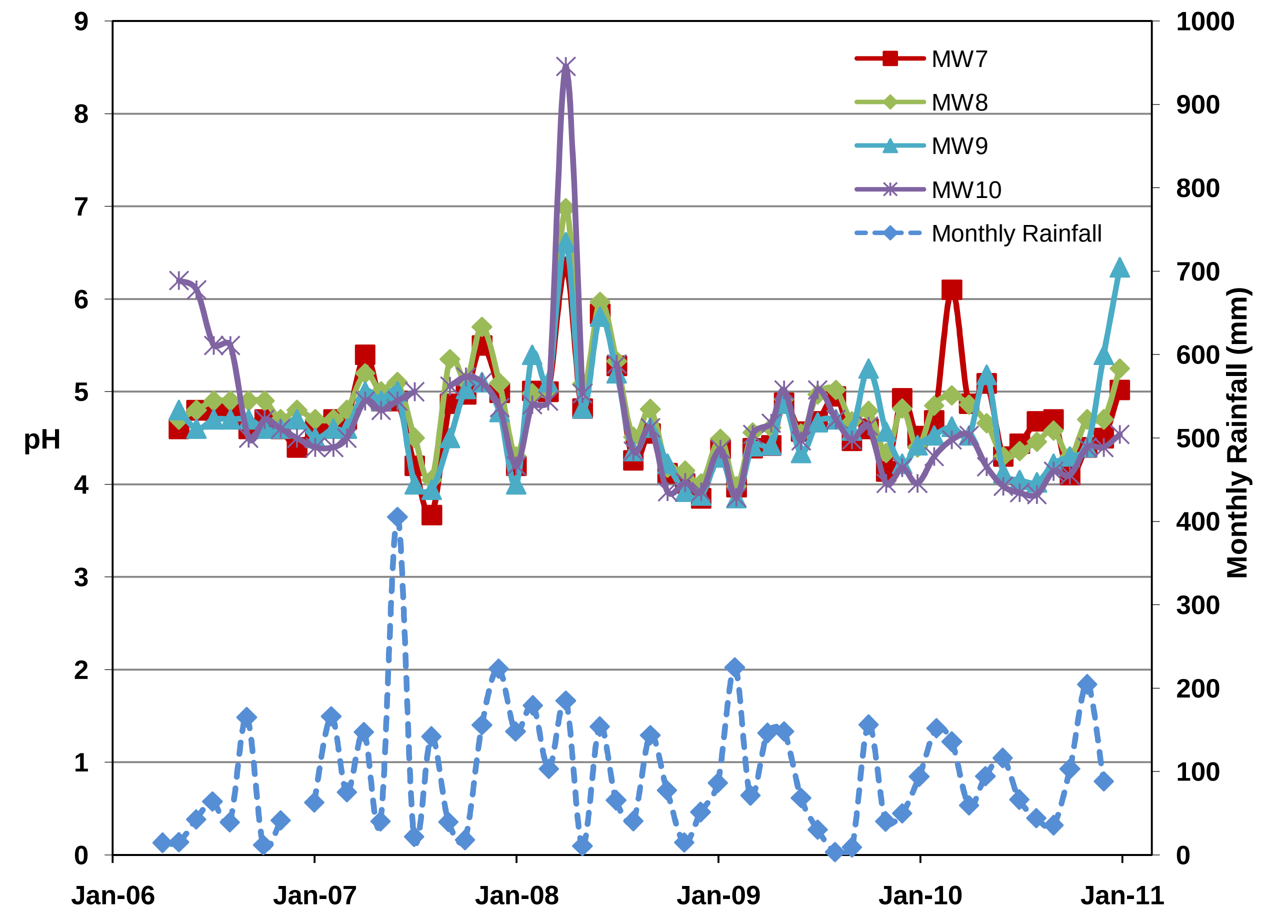
CQ4-9, CQ11S, CQ11D and CQ12 EC and PH FIGURE 13





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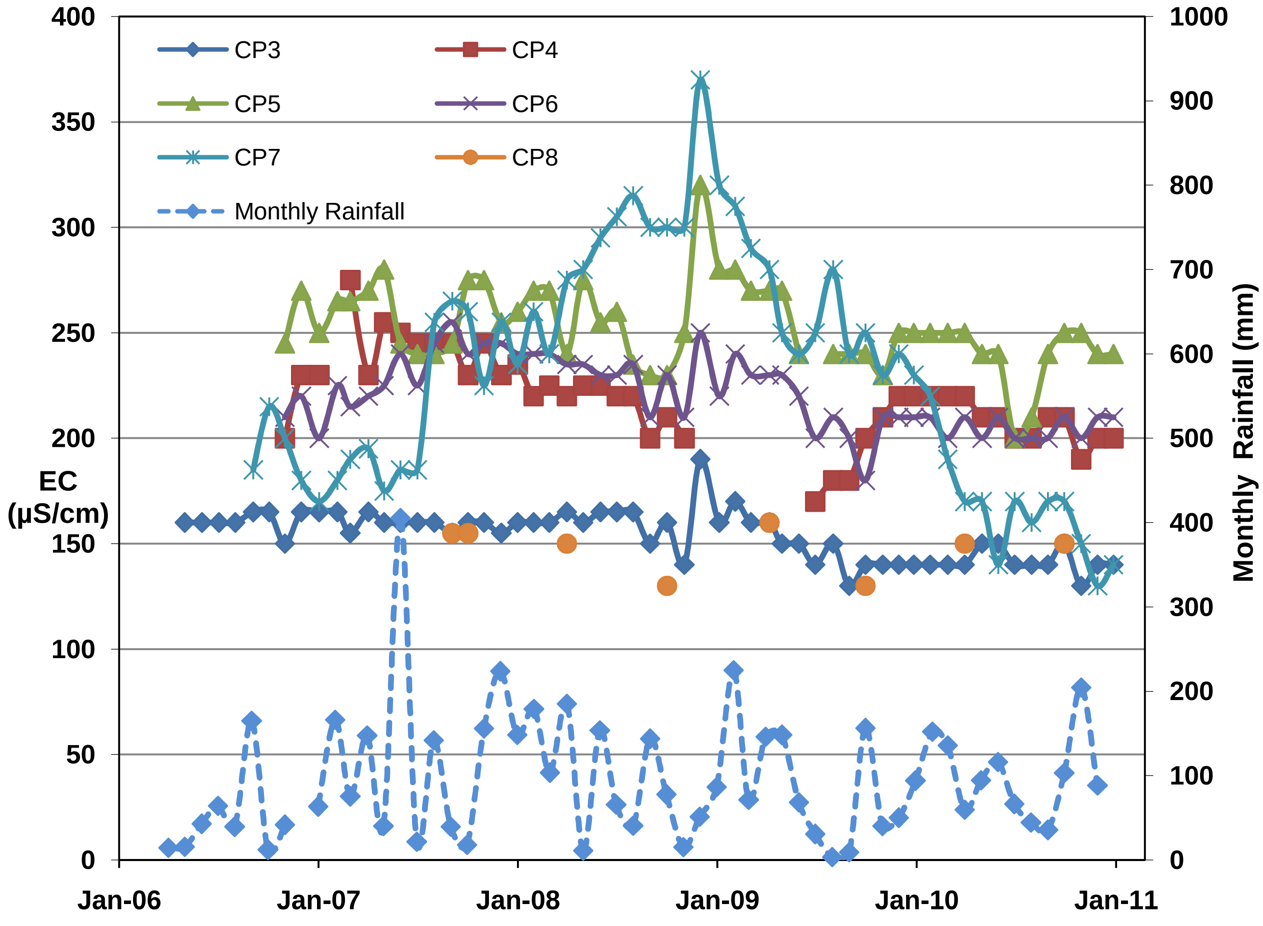
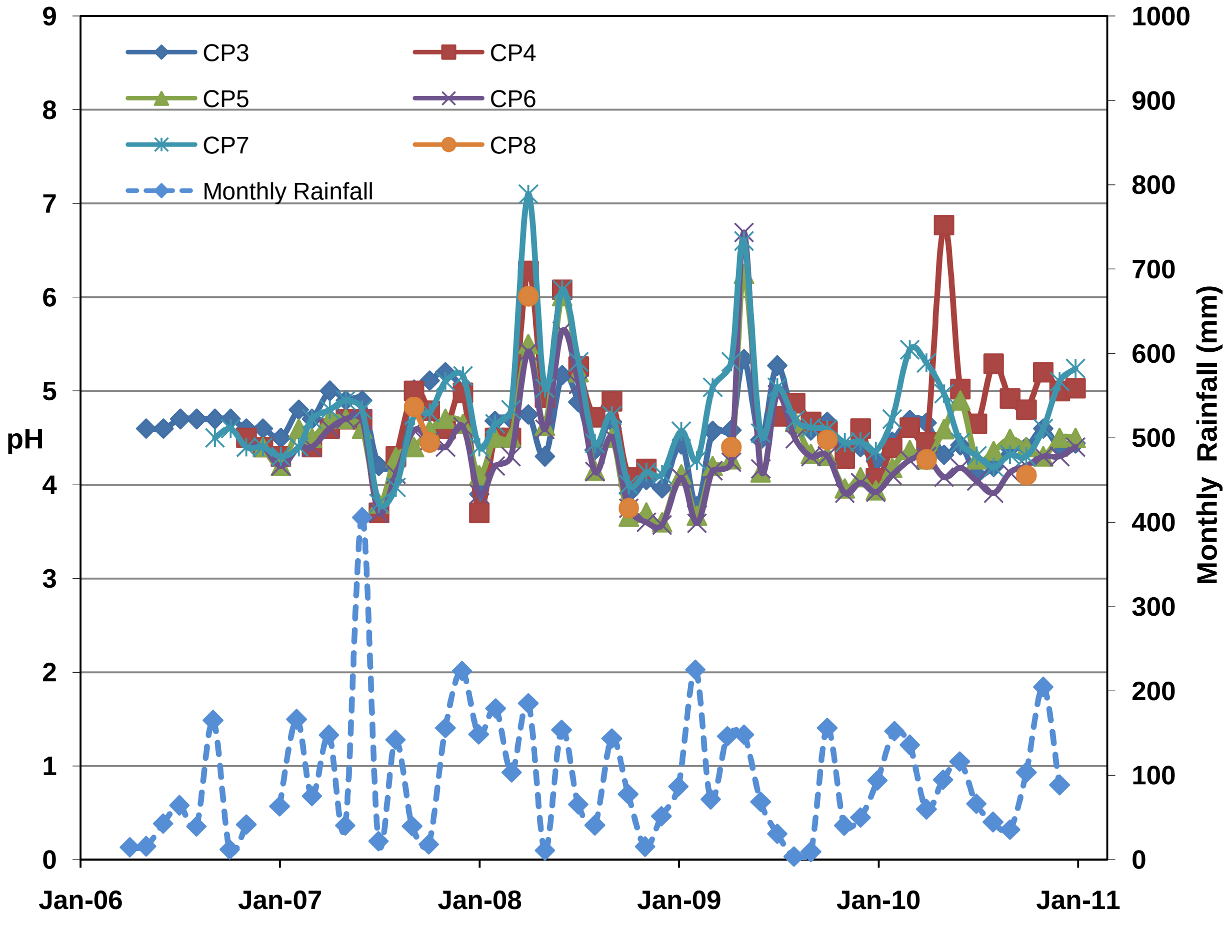
MW7-10 EC and PH FIGURE 14





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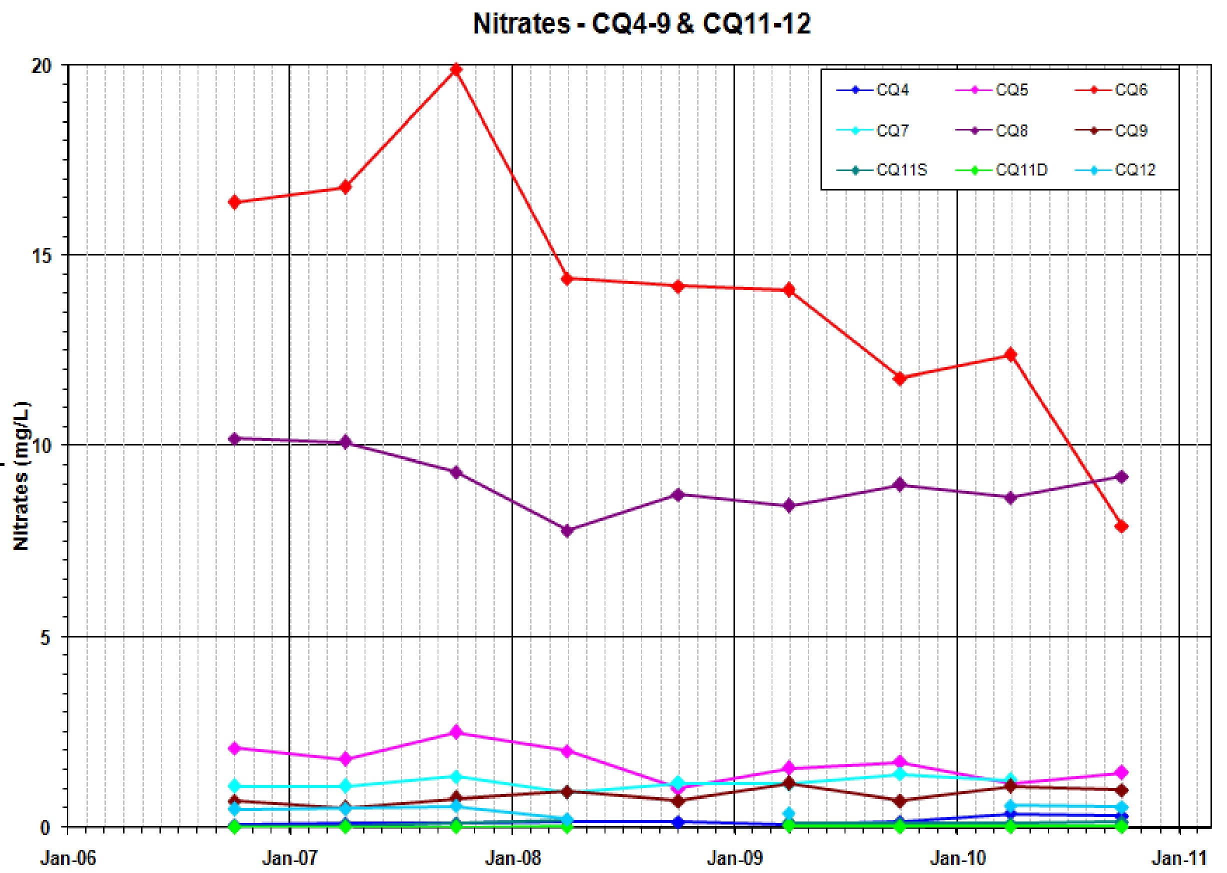
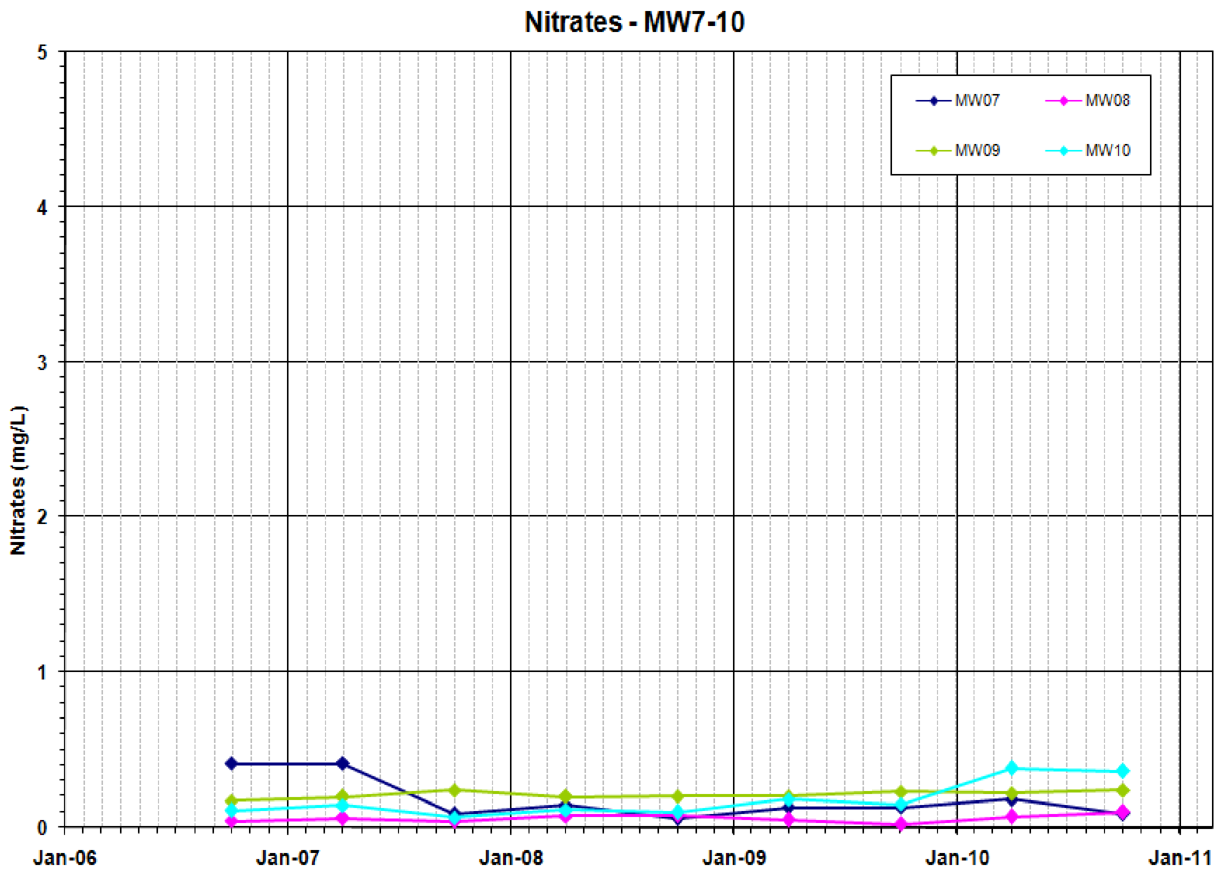
CP3-8 EC and PH FIGURE 15



Nitrates - CQ4-9 & CQ11-12
Nitrates (mg/L)
0
5
10
15
20
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
CQ11S
CQ11D
CQ12



Nitrates - MW7-10
Nitrates (mg/L)
0
1
2
3
4
5
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
MW07
MW08
MW09
MW10