AECOM

Report

Environment

TRG Developments Corp

Groundwater Well and Aquifer Assessment, Hubbles Lake, Alberta

Prepared by:

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Project Number:

60213782

Date:

May, 2011

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May 9, 2011

General Manager
TRG Developments Corp
171 New Brighton Drive SE
Calgary, AB T2Z 0E1

Project No: **60213782**

Regarding: **Allan Beach Groundwater Well and Aquifer Assessment**

Please find enclosed a copy of our report to support the licensing of the wells at the Allan Beach subdivision. The report is based on the project description provided by AECOM.

Should you have any questions about the report, please contact Michael Steed at .

Sincerely,
AECOM Canada Ltd.

Michael Steed, P.Geol.
Hydrogeologist, Environment

MS:slm

Distribution List

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3	X	TRG Developments Corp

Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	M. Steed	March, 2009	Draft
2	M. Steed	May, 2011	Final

AECOM Signatures

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Associate Vice President

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1. Introduction

AECOM was retained by TRG Developments Corp. to complete a hydrogeological assessment of the two existing water wells on their property adjacent to Hubbles Lake. The site is located in NE 9-053-01-W5M and is shown on Figure 1.0 in Appendix A. The site will be referred to in this report as Allan Beach. This report is based on the field work done in 2008 and 2009 for the previous owner of the site.

TRG Developments Corp. is planning to subdivide the property and use the existing water wells to provide potable water for the trailers in the new subdivision. There are two water wells existing on the property. One well is completed on the east end of Hubbles Lake and is referred to in this report as the East Well. It was drilled in 2004, is 51.8 meters (m) deep, is completed in a sand aquifer and has an Alberta Environmental unique well identification number of 1300047. The other well is approximately 300 m west of the East Well and is referred to as the West Well in this report. It was drilled in 1998, is 48.8 m deep, is completed in the same sand aquifer as the East Well and has an Alberta Environmental unique well identification number of 0490354.

1.1 Scope of Work

The scope of work for the project included:

- Drilling and installing an observation well located halfway between the East and West Well;
- Performing a 24-hour pump test and 24-hour recovery test on both wells;
- Collecting drawdown data from the pump well (both the East and West Well) and the observation well during the pump and recovery test;
- Collecting a groundwater sample from the pumping well during both pump tests and submitting the samples to a laboratory for routine water potability, total and fecal coliforms, total and dissolved metals, total Kjeldahl nitrogen, ammonia, phosphorus, phenols and fluoride analysis;
- Conducting a field verified well survey of the water wells that are located within approximately 1 km of both wells;
- Analyzing the drawdown data to determine the character of the aquifer;
- Reviewing and comparing the analytical test results with applicable assessment criteria; and,
- Completing an aquifer and well assessment report sufficient for licensing the well under the Water Act.

2. Regional Setting

The regional setting of the area was determined using various information sources. Information was gathered from the following sources:

- Quaternary Geology, Central Alberta (Alberta Research Council, Map 213);
- National Topographic Maps (NTS) from SoftMap software;
- *Parkland County, Part of the North Saskatchewan and Athabasca River Basins, Parts of Tp 050 to 054, R 25, W4M to R 08, W5M, Regional Groundwater Assessment; (1998)* by Hydrogeological Consultants Ltd.;

This information was analyzed to define the climate, topography, regional and local geology and hydrogeology in the subject area.

2.1 Topography and Climate

Parkland County is located in central Alberta, immediately west of the City of Edmonton. Land surface elevations within the County vary from 630 to 910 meters above sea level. The elevation generally decreases towards the east.

The climate consists of long cool summers and severe winters. The mean monthly temperature in the warmest month is above 10°C and the coolest month is below -3°C.

The mean annual precipitation average from three meteorological stations in Parkland County is 533 mm during the 1966 to 1993 period. The calculated annual potential evapotranspiration is 525 mm (Hydrogeological Consultants Ltd., 1998).

2.2 Regional Geology

The surficial geology in the County consists of discontinuous glacial and lacustrine deposits. These deposits are typically less than 20 m thick throughout most of the county expect in areas of linear bedrock lows where the thickness of the surficial deposits can exceed 100 m. The Buried Beverly Valley is one of the main linear bedrock lows in the county. It is located in the central part of the county and is orientated southwest to northeast.

The main deposits found in the county are lacustrine, ice-contact lascustrine and fluvial in origin with minor glacial moraine, organic and eolian deposits. The lacustrine, ice-contact lacustrine, and fluvial deposits are found on the eastern half of the county. These deposits are associated with the proglacial Lake Edmonton and consist of sand, silt and clay. There are eolian deposits in the southeast corner of the county. The west end of the county has ice-contact lacustrine deposits with some organic deposits consisting of woody, fibrous and mucky peat. The central area of the county which is north and south of Wabamun Lake consists of glacial moraine.

The uppermost bedrock geology in the County consists of the Tertiary and Cretaceous aged Paskapoo Formation and the Cretaceous aged Edmonton Group. The Edmonton Group has four formations consisting of the Scollard, Battle, Whitemud and Horseshoe Canyon Formations. These units are made up of interbedded shale, sandstone and coal. The Paskapoo Formation ranges in thickness within the county from 0 to 250 m and the Edmonton Group ranges in thickness from 300 to 500 m.

2.3 Regional Hydrogeology

Surficial aquifers in the County occur within two general types: sand and gravel deposits in the unconsolidated surficial material, and sandstone or fractured shale deposits in near surface bedrock.

The interbedded sand and gravel deposits usually do not have a wide areal extent nor are they very thick. The exception to this is the buried valleys that are regional aquifers. These deposits must be saturated in order for them to be aquifers. The apparent yield for the surficial wells is between 10 m^3/day (1.5 imperial gallons per minute (Igpm)) and 300 m^3/day (45 Igpm). Isolated pockets have apparent yields greater than 300 m^3/day (45 Igpm)

The bedrock wells in the area produce from all of the uppermost bedrock formations. The apparent yield for the majority of the bedrock wells is between 10 m^3/day (1.5 Igpm) and 100 m^3/day (15 Igpm).

3. Local Geology and Hydrogeology

The local geology and hydrogeology in the vicinity of the Allan Beach was determined based on the drilling records of the East Well, West Well, the observation well, and other wells drilled in the area. The drilling records are kept in Alberta Environment's (AENV) Groundwater Information System database.

3.1 Local Geology

Water well drilling reports of the wells in the area surrounding the site were used to complete geological cross-sections for the area. The location of the wells and the cross-sections are shown on Figure 2.0 (Appendix A). The cross-sections are shown on Figures 3.0 and 4.0 in Appendix A. The water well drilling reports used are in Appendix B. The Allan Beach property is located above the Buried Beverly Valley. Cross-section A-A' on Figure 3.0 is orientated perpendicular to the buried valley and Cross-section B-B' on Figure 4.0 is orientated parallel to the buried valley.

According to the drilling reports, the surficial geology is composed primarily of clay at the surface that is underlain by sand and gravel layer and then clay or till just above the bedrock. The surficial deposits in the area are approximately 40 to 60 m thick.

Bedrock is encountered at approximately a 40 to 60 m depth in most wells. The uppermost bedrock layer is the Horseshoe Canyon Formation. This formation consists of interbedded layers of shale and sandstone.

3.2 Local Hydrogeology

The cross-sections indicate that the main aquifers in the area are the Buried Beverly Valley and the sandstone in the Horseshoe Canyon Formation. Pumping rates from area wells completed in the sandstone aquifer range from 15.8 m^3/day (2.5 Igpm) to 92 m^3/day (14 Igpm). Pumping rates from area wells completed in the Buried Beverly Valley aquifer range from 31.7 m^3/day (5 Igpm) to 260 m^3/day (40 Igpm).

4. Field Investigation

4.1 Drilling

Calibre Drilling Ltd., a certified water well drilling contractor from Spruce Grove, Alberta drilled the observation well on September 23, 2008. The well was drilled with a 222.3 mm tricone bit down to a depth of 54.9 m. The lithology of the well was logged and soil samples collected at 0.76 m intervals. The observation well was drilled in between the West Well and the East Well and is approximately 150 m away from both wells.

This well encountered clay and sand layers from 0 to 53.6 mBGS. Sand units were found at 14.9 to 18.0 m, 25.6 to 34.7 m, 36.9 to 40.2 m, and 43.3 to 53.3 m. Bedrock was encountered below 53.6 m. The bedrock consisted of shale. The well's lithology log and completion details are shown on Figure 5.0 in Appendix A.

The location of the observation well is illustrated on Figure 1.0 in Appendix A.

4.2 Observation Well Installation

The Observation Well was completed with a 152 mm PVC casing on September 23, 2008 down to a depth of 50.7 m. The casing's annulus was backfilled with bentonite from 24.4 to 36.6 mBGS and drill cuttings from 24.4 to the surface. A 114.3 mm wire wrapped screen with a slot size of 12 was installed from 50.7 to 53.3 mBGS. A sand pack was backfilled around the screen from 54.9 to 36.6 mBGS. The well's completion details are shown on Figure 5.0 in Appendix A.

4.3 Pump Test

A 24-hour pump and 24-hour recovery test on the West Well was started on September 24, 2008. The pump was set at approximately 43.0 mBGS in the well. The well was pumped at a rate of 65.5 m^3/day (10 Igpm). The discharge was measured by a flow meter installed at the top of the well. The Observation Well was used as an Observation Well during the test. A water level tape was used to manually measure the water level in the West Well. A data logger was used in the observation well to measure the water level throughout the test.

A 24-hour pump and 24-hour recovery test on the East Well was started on September 29, 2008. The pump was set at approximately 27.1 mBGS in the well. The well was pumped at a rate of 98.2 m^3/day (15 Igpm). The discharge was measured by a flow meter installed at the top of the well. The Observation Well was used as an observation well during the test. A water level tape was used to manually measure the water level in the East Well. A data logger was used in the Observation Well to measure the water level throughout the test.

The pump test and recovery data is included in Appendix C and is discussed further in Section 5.0.

A water sample was collected for chemical analysis from both wells after 23 hours of pumping. The samples were submitted to Bodycote Laboratories in Edmonton, Alberta to be analyzed for routine water chemistry, total metals, dissolved metals, ammonia, total phosphorus, total Kjeldahl nitrogen, phenols, fluoride and coliforms. The analytical results are presented in Table 1.0 in Appendix D and are discussed further in Section 5.0. A copy of the analytical results can be found in Appendix E.

5. Aquifer Assessment

5.1 Hydraulic Characteristics

The data from the 24-hour pump and recovery test was analyzed using Waterloo Hydrogeologic Inc.'s Aquifer Test 4.2 software.

The Theis's analytical solution (1935) and Cooper and Jacob's modified non-equilibrium equation were used to determine the transmissivity and storativity of the aquifer using the drawdown data from the 24-hour pump test. These models were used because the wells are completed in a confined aquifer.

The recovery data for the 24-hour pump test was analyzed using the Theis recovery analysis to calculate the transmissivity and storativity of the aquifer.

The graphs associated with these methods can be found in Appendix C.

Theis's Analytical Solution

$s = (Q/4\pi T)(W(u))$

Where:

T	=	transmissivity, in m^2/day
Q	=	pumping rate, in m^3/day
s	=	drawdown at any point in the vicinity of the well, in m
W(u)	=	an exponential integral of u where $u = r^2S/4Tt$ and
r	=	distance from the well to the observation well, in m
S	=	storativity
t	=	time since pumping started, in days.

Cooper and Jacob's Modified Non-Equilibrium Equation

$T = 0.183Q/\Delta s$

Where:

T	=	transmissivity, in m^2/day
Q	=	pumping rate, in m^3/day
Δs	=	slope of the time-drawdown graph expressed as the change in drawdown across one log cycle.

Theis's Recovery Analysis

$s' = (2.3Q/4\pi T)(\log t/t')$

Where:

T = transmissivity, in m^2/day
Q = pumping rate, in m^3/day
s' = residual drawdown, in m
t = time since pumping started, in days
t' = time since pumping stopped, in days

The pump test graphs reveal that the water levels in both wells dropped quickly in the first 10 minutes of pumping and then the water level began to level out for the rest of the test. Data from the drawdown results indicate that Hubbles Lake is acting as a recharge boundary. When the graphs begin to level out, this is indication that water is being drawn from the lake. The recovery in both wells showed a quick rise in the water level at the beginning of the recovery and both wells reached 90% of the original static water level within 10 minutes (East Well) and 15 minutes (West Well) after stopping the pumps. The observation well drawdown data did not show a significant enough drawdown to analyze for transmissivity or storativity values.

Table 2.0 and 3.0 presents the calculated transmissivities and storativities for the aquifer based on the methods outlined above.

Table 2.0: Aquifer Transmissivity for the East Well

Method	Transmissivity (m^2/day)
Theis	55
Cooper & Jacob Late Curve	60
Recovery Late Curve	51
Cooper & Jacob Early Curve	2.7
Recovery Early Curve	2.9

Table 3.0: Aquifer Transmissivity for the West Well

Method	Transmissivity (m^2/day)
Theis	12
Cooper & Jacob Late Curve	10
Recovery Late Curve	13
Cooper & Jacob Early Curve	1.0
Recovery Early Curve	0.9

The analysis found two sets of transmissivity values that were an order of magnitude different for both wells. The lower of the two values is from the earlier drawdown data and does not reflect the long term capacity of the wells drawing water from the recharge boundary, Hubbles Lake. The value calculated from the later drawdown data will be used for both wells.

The average of the transmissivity values for the East Well is 55 m^2/day. The average of the transmissivity values for the West Well is 12 m^2/day. These values will be used in this report. Observation well data is considered to be more accurate when calculating storativity values than data from production wells. Since the observation well data was not able to be used and the storativity values calculated from the drawdown data are not realistic, a typical storativity value for a confined aquifer of 1.0×10^{-4} will be used in this report.

5.2 Chemical Analysis

A water sample was collected during the both pump tests as outlined in Section 4.3. The results indicate a number of exceedances of Health Canada's Guidelines for Canadian Drinking Water Quality (2007). These exceedances are for concentrations of arsenic and turbidity. Aesthetic objectives of Health Canada's Guidelines for Canadian Drinking Water Quality were also exceeded which included total dissolved solids, colour, iron and manganese. A table of results (Table 1.0) is in Appendix D and a copy of the analytical results can be found in Appendix E.

6. Well Assessment

6.1 Field Verified Well Survey

A field verified well survey was conducted by AECOM personnel from Edmonton, Alberta. The survey was conducted from December 10, 2008 to January 28, 2009. If a resident was not home, a letter was left at the residence for them to arrange a time that would be convenient for them to be contacted. The data from the survey can be found in Table 4.0 in Appendix D. The well locations are shown on Figure 6.0 in Appendix A. A search of Albert Environment's water well drilling reports website indicate that there are over 200 wells recorded within an approximate 1 km radius from the West and East Well. A summary of the water wells within approximately 1 km from the West and East Well is provided in Appendix F. The survey found information for 68 wells from well owners in the area.

6.2 Distance Drawdown

The distance-drawdown curves for each well were calculated for 1 year and 20 years of pumping at different pumping rates. The drawdown amounts and distance-drawdown curves are presented in Appendix C. The distance-drawdown was calculated using the expanded Cooper and Jacob modified non-equilibrium equation (1946):

$$s = 0.183Q/T[\ \log(2.25Tt/r^2S)]$$

<u>Where</u>:

s	=	drawdown, in m
Q	=	pumping rate, in m^3/day
T	=	transmissivity, in m^2/day
t	=	elapsed time, in days
r	=	well radius, in m
S	=	storativity

The distance-drawdown was calculated using the transmissivity value and storativity value determined previously in this report.

Three discharge rates were used; 32.7 m^3/day (5 Igpm), 65.5 m^3/day (10 Igpm) and 98.2 m^3/day (15 Igpm) to evaluate the sensitivity of the aquifer to the discharge rate.

The evaluation determined that the East Well's drawdown cone could theoretically affect wells up to 95 km away over a 20 year continuous pumping period and the West Well could affect neighbouring wells up to 44.5 km away.

There are thirty-two wells in the field verified well survey that are completed in the same aquifer as the East and West Well within a 1 km radius. A distance-drawdown calculation was performed with both wells pumping at 65.5 m^3/day (10 Igpm) continuously for 20 years using AquiferTest 4.2. An average transmissivity value was used to approximate the effects of both wells pumping at the same time. The drop in water level was calculated to be from 1.3 to 1.75 m in wells completed in the same aquifer. This corresponds to 3 to 28% drop in the available head in these wells. The 28% drop is ir [illegible] well which is 320 m from both wells.

The drawdown calculations do not take into account Hubbles Lake acting as a recharge boundary. Once the cone of depression reaches the lake, the rate of drawdown decreases as the well is pulling water from the lake. This was seen in the field during the pump tests of both wells. The cone of depression will not extend past the recharge boundary and will have less drawdown than simulated in the distance-drawdown calculations. The neighbouring wells on the north side of the lake will see little to no drop in available head and the wells south of the East and West well will not see as much drawdown as indicated in Table 4.0.

6.3 Well Efficiency

The well efficiency can be determined based on the difference between the theoretical and the actual specific capacity in the pumping well at a given time. The theoretical specific capacity was calculated using the following equation:

$$Q/s = 4\pi T/[2.3 \log(2.25Tt/r^2S)]$$

<u>Where</u>:

Q/s	=	specific capacity
T	=	transmissivity, in m^2/day
t	=	elapsed time, in days
r	=	well radius, in m
S	=	storativity

Using the calculated aquifer values for the East Well, the result of this calculation was a specific capacity of 36 m^3/day/m. Using an average value of the early curve transmissivity, a specific capacity of 2.7 m^3/day/m was calculated. The actual specific capacity of the East Well was calculated by dividing the pumping rate by the drawdown. The actual specific capacity of the well was calculated to be 9.9 m^3/day/m. The efficiency of the well is calculated to be 28% for the early curve values and 370% for the late curve data. Well efficiency is generally expected to be between 60 and 80%. The actual specific capacity is an average of the specific capacity of the aquifer and Hubbles Lake. The early curve specific capacity is much lower than the actual because this data is before the well was drawing water from Hubbles Lake. The late curve specific capacity is much higher than the actual because this data reflects the recharge portion of the drawdown test.

Using the calculated aquifer values for the West Well, the result of this calculation was a specific capacity of 8.5 m^3/day/m. Using an average value of the early curve transmissivity, a specific capacity of 0.83 m^3/day/m was calculated. The actual specific capacity of the West Well was calculated by dividing the pumping rate by the drawdown. The actual specific capacity of the well was calculated to be 3.7 m^3/day/m. The efficiency of the well is calculated to be 44% for the early curve values and 450% for the late curve data. Well efficiency is generally expected to be between 60 and 80%. The actual specific capacity is an average of the specific capacity of the aquifer and Hubbles Lake. The early curve specific capacity is much lower than the actual because this data is before the well was drawing water from Hubbles Lake. The late curve specific capacity is much higher than the actual because this data reflects the recharge portion of the drawdown test.

An accurate well efficiency was not able to be calculate because of the effects of Hubbles Lake being a recharge boundary for the wells.

6.4 Groundwater Under the Direct Influence of Surface Water (GWUDI) Assessment

The protocols outlined in Alberta Environment's *Assessment Guideline for Groundwater Under the Direct Influence of Surface Water* (GWUDI) were used to assess the aquifer that the East and West Well are completed in. A letter outlining the results of the assessment was sent to Harshan Radhakrishhnan of Alberta Environment on November 17, 2008.

The results of this assessment indicate that both wells are completed in the Buried Beverly Valley. According to the University of Alberta's Atlas of Alberta Lakes (http://sunsite.ualberta.ca/Projects/Alberta-Lakes) the maximum depth of Hubbles Lake is approximately 30 m. At this depth, the lake bottom is within the sand deposits of the buried valley. The depth of penetration of Hubbles Lake into the aquifer is illustrated on Cross-section A-A'. The West Well is approximately 80 m south of Hubbles Lake and the East Well is approximately 50 m east of the lake.

Based on this information, it was concluded that both wells are under the direct influence of surface water. The drawdown information from the pump tests also indicates that the wells are drawing water from the lake.

7. Conclusions

An observation well was drilled in between the East and West Well. The observation well was completed in the same aquifer as the other two wells and is approximately 150 m away from both wells.

A 24-hour pump and recovery test was conducted on West Well from September 24 to 25, 2008. A pumping rate of 65.5 m^3/day (10 Igpm) was maintained during the pump test on the well. The total drawdown in the West Well after 24 hours of pumping was 9.9 m. The well was allowed to recover and reached 90% of the static water level after 10 minutes.

A 24-hour pump and recovery test was conducted on East Well from September 29 to 30, 2008. A pumping rate of 98.2 m^3/day (15 Igpm) was maintained during the pump test on the well. The total drawdown in the East Well after 24 hours of pumping was 17.7 m. The well was allowed to recover and reached 90% of the static water level after 15 minutes.

The transmissivity and storativity of the aquifer was calculated using three different methods of analysing data from the both wells. The transmissivity value was found to be 55 m^2/day for the East Well and 12 m^2/day for the West Well. A storativity value of 1.0×10^{-4} was estimated for the aquifer.

The 20 year sustainable yield (Q20) for the aquifer was calculated using the Farvolden Method. The Q20 was determined to be approximately 513 m^3/day (78 Igpm) for the East Well and 66 m^3/day (10 Igpm) for the West Well.

The drawdown effect of the wells was calculated assuming both wells will have a constant pumping rate of 65.5 m^3/day (10 Igpm) for a period of 20 years. There are records for over 200 wells within a 1.0 km radius from both wells. The field verified wells survey gathered information on 68 wells with 32 wells completed in the same aquifer as the East and West Wells. Pumping both wells continuously for 20 years at 65.5 m^3/day (10 Igpm) would induce a drawdown of 1.75 m on the closest well which will be 8% of the available head in that well. well would have the largest drop in available head of 28%. This is assuming continual use of the well over 20 years. It is our understanding that the well will be used intermittently allowing for the aquifer to recover and this analysis does not take into account the recharge from Hubbles Lake.

A water sample was collected from the both wells during their pump tests. Both samples exceeded the requirements of Health Canada's Guidelines for Canadian Drinking Water Quality (2007) for iron, manganese, total dissolved solids, colour, turbidity and arsenic. It is our understanding that a water treatment system is proposed for the development.

Both water wells produce groundwater that is under the influence of surface water as Hubbles Lake recharges the aquifer.

8. Recommendations

Based on the sustainable yield calculations, the East Well can continuously produce at a rate of 513 m^3/day (78 Igpm) and the West Well can continuously produce at a rate of 67 m^3/day (10 Igpm) for a period of 20 years. Based on the testing, results and anticipated demand, AECOM recommends that both wells be licensed at a rate of 65.5 m^3/day (10 Igpm). A higher pumping rate can be sustained for short periods of time as long as the aquifer is allowed to recover.

Appendix A

Figures

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Licensing Groundwater Wells
Hydrogeological Assessment

Site Plan and Well Locations

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Figure 1.0

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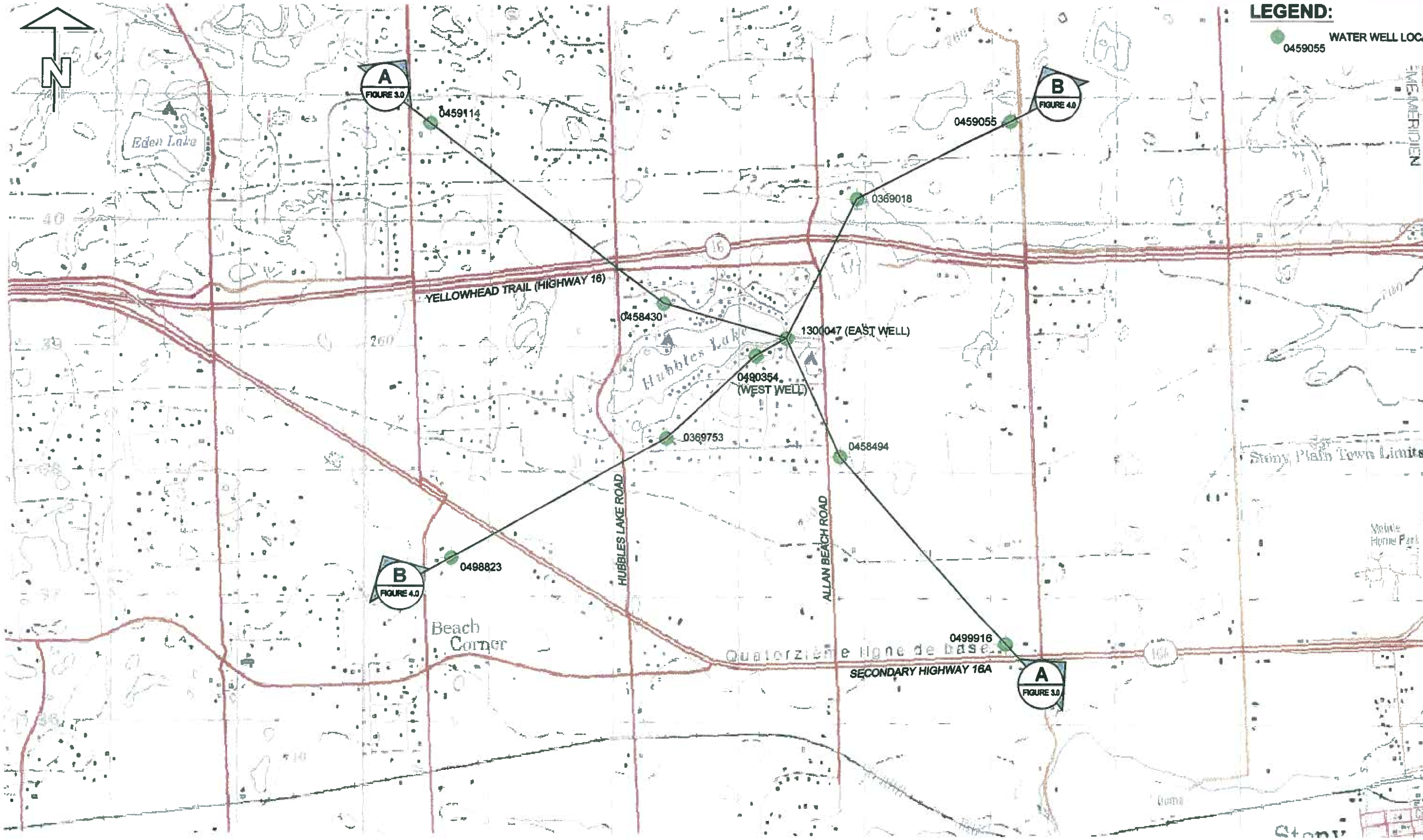

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Water Well Location Plan

Figure 2.0

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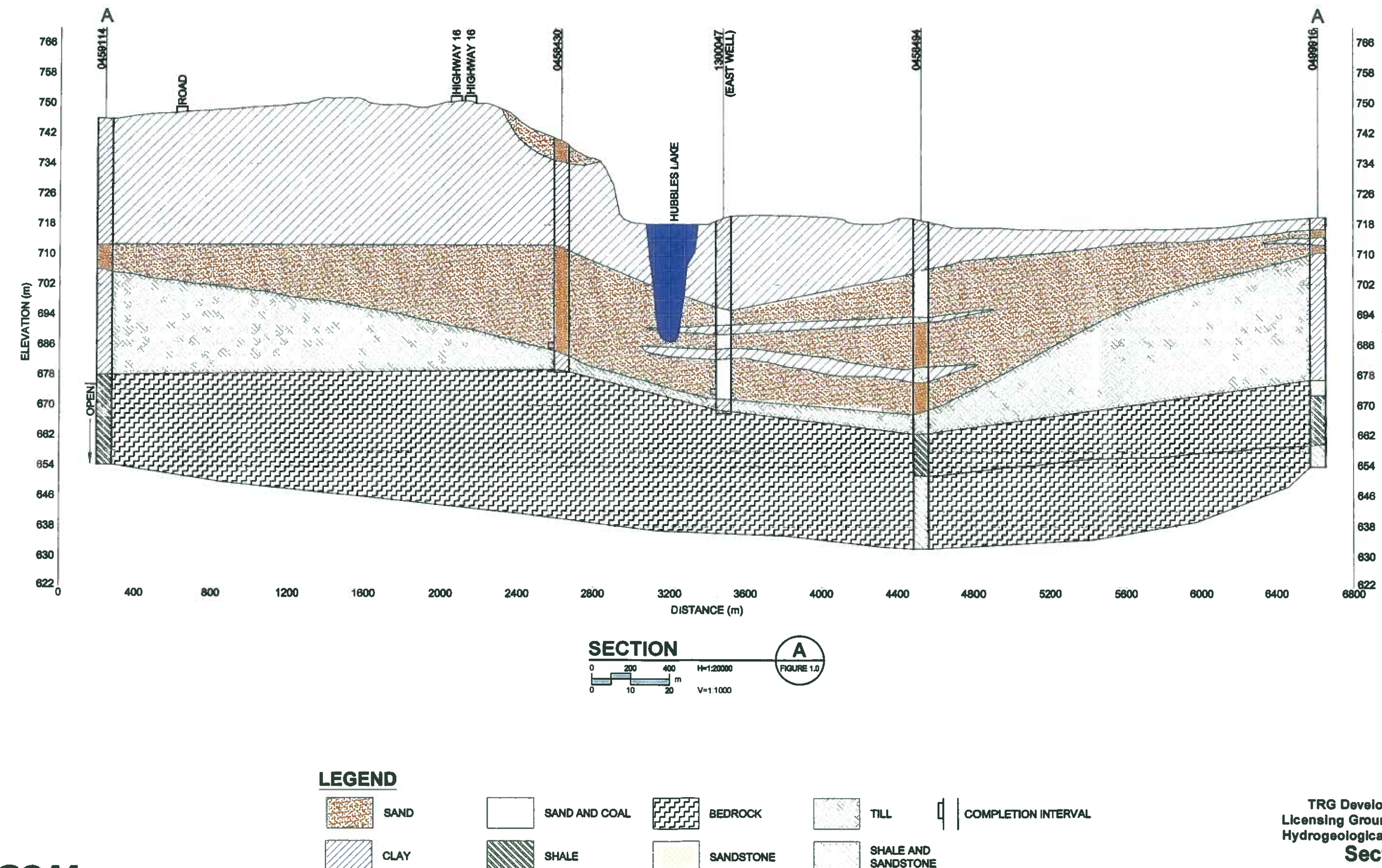

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Section A-A'

Figure 3.0

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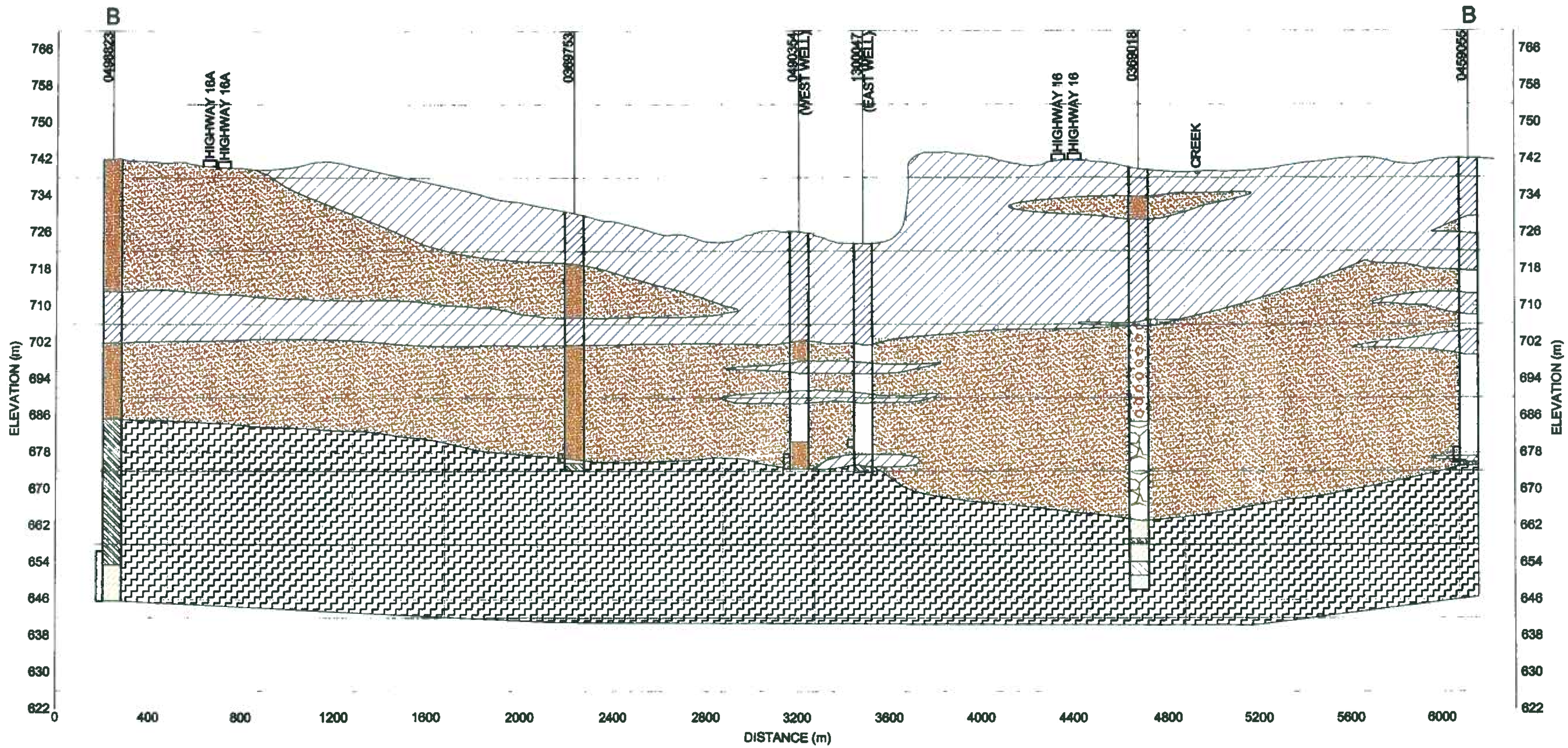

SECTION B FIGURE 1.0

0 200 400 m H=1:20000
0 10 20 V=1:1000

LEGEND

SAND	CLAY
SAND AND COAL	SHALE
BEDROCK	SANDSTONE
GRAVEL	SHALE AND SANDSTONE
SAND AND GRAVEL	COMPLETION INTERVAL

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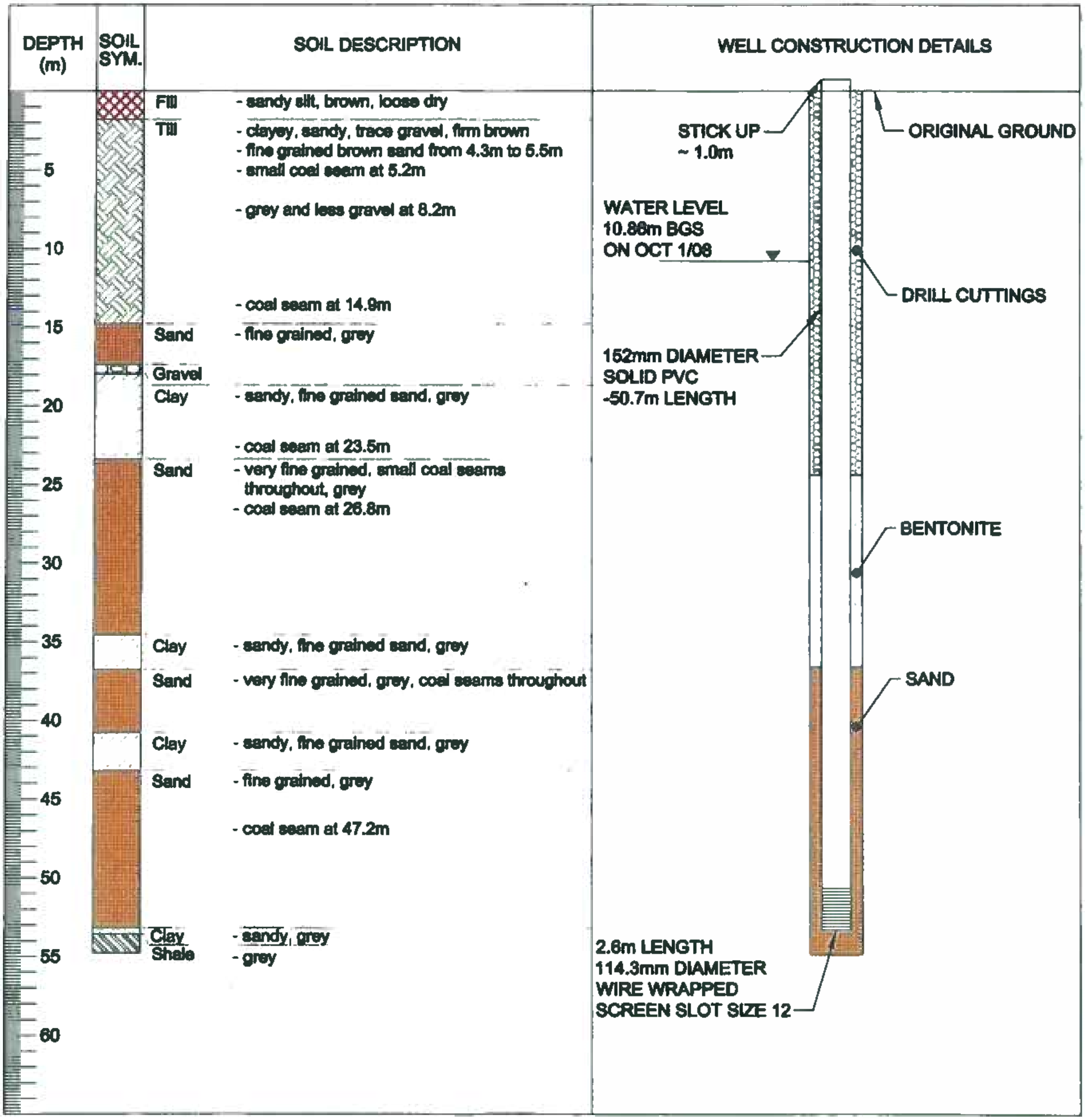
Section B-B'

Figure 4.0



CONTRACTOR:	CALIBRE DRILLING Ltd.
RIG TYPE:	AIR ROTARY
BOREHOLE SIZE:	222.2mm (BIT SIZE)
GROUND ELEVATION:	737 AMSL (GPS)
COORDINATES (UTM):	N: 5 938 970 E: 693 252 (GPS)
DATE DRILLED:	SEPTEMBER 23, 2008
DATE WELL INSTALLED:	SEPTEMBER 23, 2008
LOGGED BY:	MS
AENV UNIQUE WELL ID:	1165353

0 2 4 8 m SCALE 1:400

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Hydrogeological Assessment

Observation Well
Borehole Log and Completion Details
Figure 5.0

AECOM

0 50 100 200 m SCALE 1:10000

ISS/REV: A
AECOM FILE NAME: 6021378200-B-F06_RA.dwg Saved By: fierhellerj PLOT: 2011-05-11 2:59:50 PM B SIZE 11" x 17" (279.4mm x 431.8mm)

AECOM

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Distance-Drawdown for 20 years Pumping 65.5 m3/day (10 Igpm)

Figure 6.0