THURBER ENGINEERING LTD.

December 17, 2013 File: 17-336-3

Regional District of Nanaimo
6300 Hammond Bay Road
Nanaimo, BC V9T 6N1

Attention: Mike Donnelly

2012-2013 ANNUAL GROUNDWATER MONITORING REPORT
RDN SAN PAREIL WELL FIELD

Dear Mike:

Thurber Engineering Ltd. (Thurber) is pleased to provide this report summarizing groundwater monitoring at San Pareil in 2012-2013.

Use of this letter report is subject to our Statement of Limitations and Conditions, located after the figures.

1. INTRODUCTION AND BACKGROUND

Thurber was retained by the Regional District of Nanaimo (RDN) in 2010 to conduct a ground water under direct influence of surface water (GWUDI) investigation for 2 active production wells (Well #1 and Well #4) at the San Pareil Well Field.

The initial GWUDI investigation[1] was undertaken using the draft guidelines available at the time[2] and resulted in an 'indeterminate' risk status for the subject wells. After collection of further monitoring data and upgrades to one of the well heads, a follow-up study was conducted[3]. The result of the follow-up study was that the wells were 'at risk' of containing pathogens from a GWUDI situation. The follow-up study made the following recommendations:

- Continuing water level monitoring in the select wells and the wetlands.
- Continuing monthly raw water sampling in the dry months (June to October) and initiating bi-monthly (i.e. twice per month) sampling in the wet months (November to May) for bacteriological analyses (*E. coli* and total coliforms).

[1] Thurber Engineering Ltd., Regional District of Nanaimo San Pareil Wells GWUDI Investigation, May 31, 2010.
[2] Kohut A., Draft 5 Guidance Document for Determining Ground Water at Risk of Containing Pathogens Including Ground Water Under Direct Influence of Surface Water, Province of British Columbia, 2009.
[3] Thurber Engineering Ltd., Revised GWUDI Follow-up Study RDN San Pareil Well Field, September 18, 2013.

- Initiating bi-annual (i.e. twice per year) sampling for particulate size distribution analysis and annual microscopic particulate analysis (MPA) on each well on alternating years to confirm adequate filtration is occurring.

- Annual review of the sampling data to assess aquifer filtration performance.

This document provides a summary and interpretation of the groundwater monitoring data collected at San Pareil from March 2012 to September 2013. It is our understanding that this report will be submitted to the Vancouver Island Health Authority (VIHA).

2. METHODOLOGY

Collection of continuous groundwater level data has been ongoing in San Pareil observation wells MW1, MW2, production Well #4, and the wetland stilling well since 2010. Continuous monitoring was also initiated in production Well #1 in November 2012. Figure 1 shows the location of wells at San Pareil. Each of the monitored wells have data-logging transducers that are capable of measuring temperature and pressure. During monthly downloading of the dataloggers, manual water level measurements were made.

Both pumping wells were sampled for the following:

- Total coliform and *E. coli* on September 25, November 5, November 21, December 6, and December 19, 2012, and January 17, January 30, February 14, March 14, March 27, April 18, April 25, May 16, June 12, July 10, August 14, and September 18, 2013

- Full raw water chemistry analysis, including major dissolved ions and total metals, on October 17, 2012

- Particle size distribution analyses on November 6 and December 19, 2012 and September 19, 2013

- MPA on Dec 19, 2012 and September 19, 2013

Chemical and bacteriological analyses were tested by North Island Laboratories, particle count analyses were done at the University of British Columbia, and MPA were conducted by Hyperion Research Ltd. Laboratory data sheets are attached.

3. RESULTS

3.1 Water Level Monitoring

Continuously and manually-monitored water elevations in the selected wells during the 2012-13 monitoring period are compiled in Figure 2.

Water elevations and trends in the shallow aquifer continue to closely match those of the nearby wetlands and Englishman River. The water levels fluctuated on the order of 1 m in the wet

season which approximately extended to June of 2012, began again in early October 2012, and continued to mid-July 2013. Drawdown of approximately 0.3 m and from 1.5 to 2.5 m is seen in Well #1 and Well #4, respectively. Interference drawdown on the order of up to 0.5 m occurs in MW2 due to pumping Well #4.

3.2 Groundwater Quality Sampling

The results of bacteriological analyses are summarized in Table 1.

DATE	WELL #1 (MPN/100 mL)		WELL #4 (MPN/100 mL)	
	Total coliforms	*E. coli*	Total coliforms	*E. coli*
Sept 25/12	**4.2**	<1.0	<1.0	<1.0
Oct 17/12	**2.0**	<1.0	**1.0**	<1.0
Nov 5/12	**>200.5**	<1.0	**>200.5**	<1.0
Nov 21/12	**5.3**	<1.0	**47.8**	<1.0
Dec 6/12	**7.5**	<1.0	**16.4**	<1.0
Dec 19/12	**1.0**	<1.0	**6.4**	<1.0
Jan 17/13	**1.0**	<1.0	**1.0**	<1.0
Jan 30/13	**1.0**	<1.0	<1.0	<1.0
Feb 14/13	**1.0**	<1.0	**1.0**	<1.0
Mar 14/13	**1.0**	<1.0	<1.0	<1.0
Mar 27/13	**1.0**	<1.0	<1.0	<1.0
Apr 18/13	<1.0	<1.0	**1.0**	<1.0
Apr 25/13	<1.0	<1.0	**1.0**	<1.0
May 16/13	<1.0	<1.0	<1.0	<1.0
Jun 12/13	**1.0**	<1.0	<1.0	<1.0
Jul 10/13	<1.0	<1.0	<1.0	<1.0
Aug 14/13	**3.1**	<1.0	<1.0	<1.0
Sept 18/13	**13.7**	<1.0	**1.0**	<1.0

Note: bold, underlined numbers indicate values exceeding the Guidelines for Canadian Drinking Water Quality maximum acceptable concentrations of none detectable per 100 mL at the point of consumption

The results of the October 17, 2012 full chemistry scan were compared to the Guidelines for Canadian Drinking Water Quality and all analyzed parameters in the water samples from both wells were below the aesthetic objectives and maximum acceptable concentrations at the time tested, with the exception of total coliforms concentrations (Table 1). The October 2012 sampling results are summarized in Table 2 attached.

According to the Ontario GWUDI procedure[4], particle count analysis can be used to assess aquifer filtration. A particle count per mL in the water that is consistently less than 100 with a size that is greater than 10 µm is one line of evidence for adequate filtration. The particle

[4] Ontario Ministry of the Environment, Terms of Reference for Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water, October 2001.

counts per mL with a size greater than 10 µm for the samples obtained on November 2012, December 2012, and September 2013 were respectively: 36, 24, and 0 for Well #1 and 180, 12, and 16 for Well #4. Note that the particle count of 180 at Well #1 is significantly higher than the recommended threshold.

MPA sampling in December 2012 (Well #4) and September 2013 (Well #1) resulted in respective risk factors of low (0) and moderate (14) according to the EPA Consensus Method rating system. No evidence of *Giardia* or *Cryptosporidium* cysts and oocysts were found in the samples, however, a significant amount of algae and plant debris were observed in the sample taken from Well #1.

4. CONCLUSIONS AND RECOMMENDATIONS

Similarity in water levels/trends and consistent detection of total coliforms, including increased total coliforms concentrations in the wet season, reaffirms the 'at risk' GWUDI designation for the San Pareil wells. In addition, MPA and particle count results summarized herein suggest aquifer filtration may not be adequate to reliably remove bacteria and protozoans.

There is presently no mainstream method of sampling and analyzing for viruses in water. The current GWUDI guidelines[5] suggest that the presence of total coliforms implies the occurrence of other human microbial pathogens, such as viruses and protozoa. Although there are 'no known potential sources of pathogenic contamination within at least 30 m of the wells'[1], viruses tend to be much smaller in size (typically ranging from <0.02 µm to 0.9 µm) than bacteria and protozoans, therefore the travel distances can be much greater for viruses. In addition to protozoan and bacterial, these wells are therefore also considered at risk of viral contamination. VIHA requires '4 log inactivation' of viruses which is typically done through chlorination, the current method of disinfection employed at San Pareil.

It is recommended that the level of treatment of the water produced from this well field reflect the results found in this study. Water treatment is not within Thurber's area of expertise. We understand that the RDN is considering a dual disinfection approach to treatment of the groundwater produced at San Pareil (chlorination and ultraviolet light).

Annual MPA sampling of the San Pareil wells should be maintained. Frequent turbidity measurements on the raw well water should also be conducted to establish a long term record from the wells and confirm that adequate treatment is being employed.

[5] MOH, Health Protection Branch, Population and Public Health Division, Guidance Document for Determining Ground Water at Risk of Containing Pathogens (GARP) Including Ground Water Under Direct Influence of Surface Water (GWUDI), Version 1, April, 2012.

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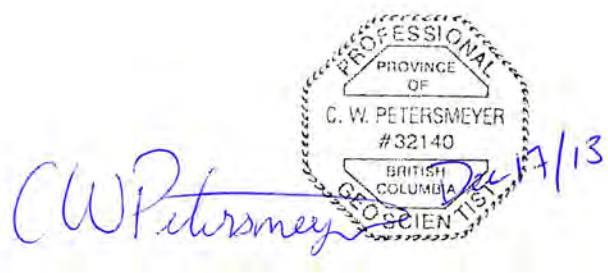
5. CLOSURE

We trust the above provides the information you require at this time. If you have any questions, please contact the undersigned at your earliest convenience.

Yours truly,
Thurber Engineering Ltd.
Kevin Sterne, P.Eng.
Review Principal



Chad Petersmeyer, P.Geo.
Hydrogeologist

Attachment

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REGIONAL DISTRICT OF NANAIMO
2012-2013 ANNUAL GWUDI MONITORING REPORT - SITE PLAN

SCALE 1:750

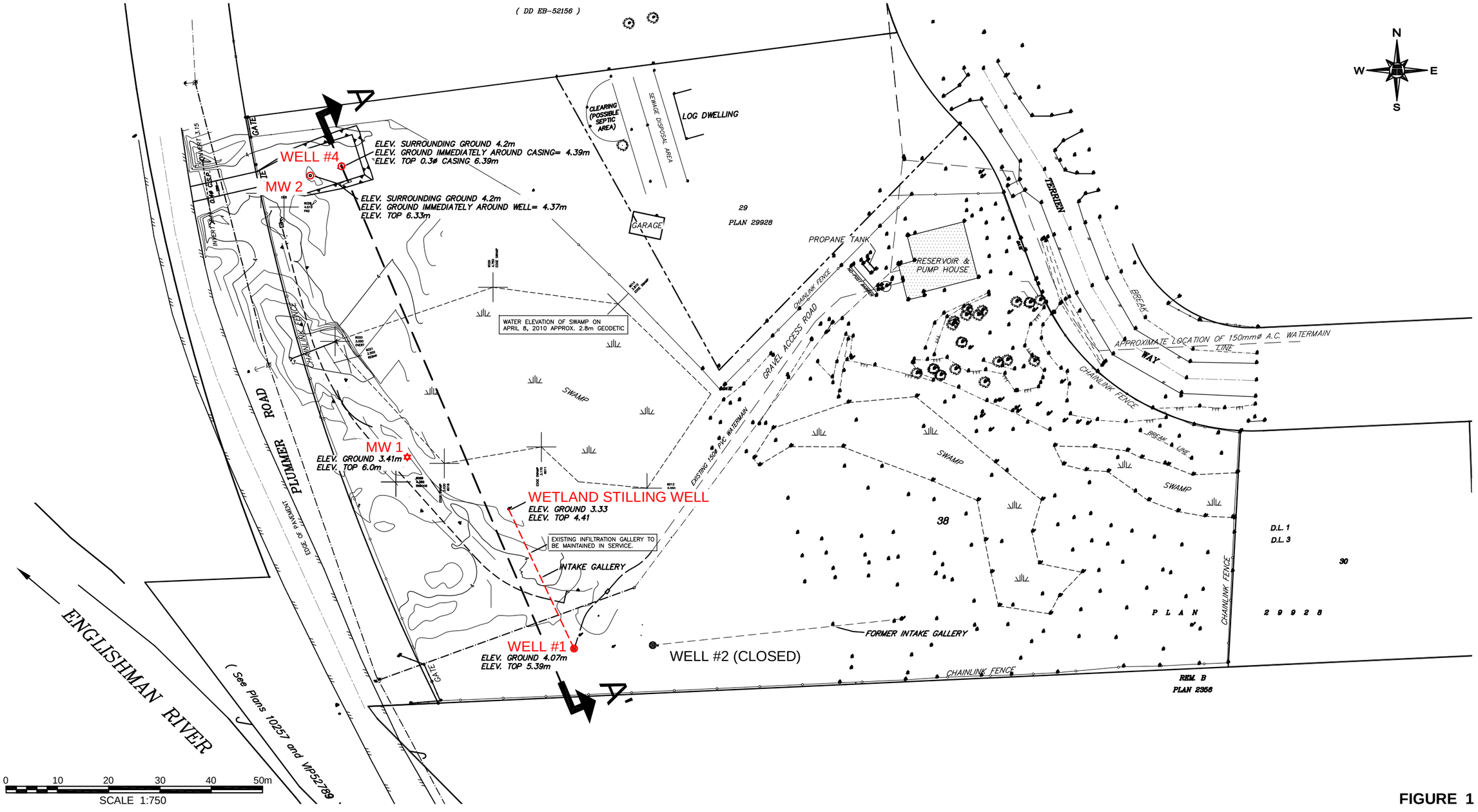

FIGURE 1

Client: Regional District of Nanaimo
File No.: 17-336-3
E-File: TED04243.dwg

Date: October 8, 2013