31/08/2020

Submission regarding RESOURCE CONSENT HEARING REQ.596300 – AUPOURI AQUIFER WATER USER GROUP – 24 RESOURCE CONSENT APPLICATIONS FOR GROUNDWATER TAKES FROM THE AUPOURI AQUIFER FOR HORTICULTURAL IRRIGATION

Summary Position

I seek the council to refuse the block resource consent, because of the uncertainties and risks involved.

Background of Submitter

My name is Alan Gordon Nunns. I am the property owner of Lot 9 DP 153818 at 9 Harry's Lane, Pukenui 0484. I am the direct descendant of Henry James Lamb who settled in Pukenui in 1891, and his son Harry Lamb (my grandfather) who was a pioneer farmer in the area. I have a water well on my property which was drilled with consent in 2006. The well has been used to establish over 700 native trees and plants on the property, using drip irrigation as needed during the summer months. These trees have created a pleasing visual amenity in Pukenui and have attracted an increasing number of native birds. When I build on the property in the next few years, I plan to use the water for domestic use and for personal vegetable gardening.

My professional background is that I have a BSc (Hons) First Class in Geology from Auckland University where I was Senior Scholar in Science, and a PhD in Geological Sciences from the University of Durham, U.K., where I was a Commonwealth Scholar from NZ. For 24 years I worked in earth science research, oil field operations, and senior technology management for Chevron Corporation, retiring as General Manager of Global Technology and Strategy. For a subsequent ten years I have owned my own company, which creates technical geological software for the global oil industry using novel quantitative techniques for modeling and analyzing complex geological structures. This software is used by large and small companies as well as many universities including Harvard, University of Texas and Imperial College, London.

Throughout my career I have had direct experience in the approaches and techniques used for modeling and managing oil and gas reservoirs and a good understanding of the uncertainties and risks involved. These approaches and techniques are similar but not identical to those used in aquifer modeling and management.

Approach

I reviewed the technical reports provided by the NRC including the 2015 Lincoln Agritech (LA2015) study of the Aupouri aquifer and the various Williamson Water and Land Advisory (WWLA) reports that pertain directly to the block application. I have reviewed what I could find of the sparse scientific literature dealing with surface and subsurface geology of the Aupouri peninsula. I have also reviewed the NZ guidelines for the monitoring and management of seawater intrusion risks on groundwater, and the NRC policy statements and regional plan as they deal with groundwater.

For comparison I also reviewed the most recent sustainable management plan for the Lower Hutt aquifer (HAM3), which exemplifies a thorough and scientific approach to the study and management of an important coastal aquifer. Most of my comments relate to subsurface characterization but I have also made some observations regarding water balance and social and economic impacts. I thank my son, Peter Nunns, for the economic data at the end of this submission, which he summarized from government data.

Observations Regarding the Aupouri Aquifer

The Aupouri aquifer is narrow, shallow, and fragile, because it is surrounded by sea and sits above basement rock that is not far below sea level. The aquifer is recharged by rainfall over a narrow strip of land. The proposed water withdrawals represent a significant proportion of the current estimated recharge rate and there are permeability barriers within the system that impede the recharge of the deeper productive units. If improperly managed, the aquifer can easily be partially destroyed in a few decades by sea- water intrusion or contamination. While the future impacts of climate change are unknown, it possible that the Far North is entering a period of droughts mixed with intermittent heavy rains that induce high runoff, which may impair the future recharge rates relative to historic averages.

The Aupouri aquifer represents a valuable natural resource that should be sustainably managed on a multi-century timescale, for both community populations and commercial enterprises such as avocado orchards. There are many instances around the world where much larger and more robust aquifers have been depleted and damaged in a relatively short time due to inadequate understanding and poor management practices. Northland should strive to avoid similar mistakes.

Sustainable aquifer management depends on the thorough characterization of three interrelated natural systems: the climatic system, the surface topographic and hydrologic system, and the subsurface geological and hydrologic system (including the marine interface). It is only after these three natural systems have been thoroughly characterized, that there can be reliable hydrologic modeling and effective deployment of extraction and monitoring equipment.

Of the three natural systems, it is the subsurface system that is often most poorly characterized and is the most likely to produce unpleasant surprises, particularly at early stages when there have been relatively few wells drilled.

The subsurface geology and hydrology of the Aupouri Peninsula is dramatically under-sampled by the available wells (average well spacing 400 hectares), meaning that the overall subsurface structure is undoubtedly more complex than the model representation. This means that any current predictions made by WWLA model may be unreliable, which is a common occurrence in early stage reservoir and aquifer modeling. The consequence of this probable unreliability is that the model may over-estimate sustainable flows substantially, and under-estimate the risk of saline intrusion.

In the following sections I discuss the most important uncertainties in the subsurface characterization.

For reference, Figure 1 shows a highly schematic cross-section across the Aupouri peninsula from the LA2015 report. The stratigraphic succession consists of a lower marine unit of shell beds, sands and silts surmounted by an upper terrestrial sequence of dune sands, peats, clay layers, and diagenetic pans, sitting upon a basement rock surface that dips from east to west.

Basement Geology and Topography. The basement rocks are Permian-Cretaceous in age. The basement surface is a critical surface for the aquifer system because the most permeable aquifer unit lies immediately above. Figures 2 and 3 below contrast the LA2015 and WWLA estimates of depth to basement.

The LA2015 map is based on well data, partially constrained by limited seismic refraction and gravity data. Based on an inference from aeromagnetic data (Stagpoole et al., 2012), the LA2015 authors have included a faulted contact between the Mt Camel Terrane and the Caples Terrane running from The Bluff towards Karikari Peninsula, deepening the basement significantly towards the west.

The elevations in the maps differ very significantly (by up to 150 m).

In areas of close well coverage both maps show significant topographic relief on the basement (although the contours differ in detail). This is hardly surprising, as the outcropping Mt Camel volcanic rocks on the eastern side of Houhora show rugged topography. Looking across Houhora Harbour to Mt Camel you can appreciate that the basement rocks under the main part of the peninsula will also likely feature local buried hills and valleys, which will have a significant impact on local subsurface hydrology.

With respect to the LA2015 map, the overall western basement slope in the central part of the peninsular is probably consistent with refraction data from Hukatere (which I haven't seen), and is certainly consistent with the overall westerly tilting of Northland that occurred in the Miocene. However, I consider it unlikely that there is a large distinct fault scarp along the boundary between the Mt Camel and Caples terrane (LA2015), because the terrane collision would have occurred at least 23 million years ago and there would have been ample opportunity for a fault scarp to be degraded. However, there may be buried geomorphic features related to differences in basement rock types.

Conversely, the WWLA map appears to be based on naïve computer interpolation without regard to any informed geological hypotheses in areas where there is no well data. I note that in the oil industry naïve computer-generated maps are universally disallowed unless there is close well or geophysical control, because of their inherent unreliability.

The depth and topographic nature of the basement surface is hardly inconsequential for the development of the Aupouri aquifer, particularly given that the shell bed unit lies directly on basement. The basement topography influences both the depositional facies and distribution of overlying sediments and the three-dimensional hydrological flow.

Sedimentary Stratigraphy.

The lithological variation from well to well within the sediments of the aquifer is extreme (Figure 4), particularly for units that lie below the level of the widespread Holocene peat deposits that occur close to sea level. In consequence, the interpolation of physical properties to areas away from well control using kriging is almost certain to lead to unreliable models. The hydraulic conductivity of various units within the sequence varies by a factor of over 100. In the LA2015 and WWLA models the vertical anisotropy for lumped layers is estimated using PEST optimization of well pressure data..

Surprisingly, there seems to be very little age control of any the units, and neither LA2015 or WWLA have developed a coherent geological history for the entire aquifer succession.

As far as I can tell, there has been no attempt to establish the age of the lower marine sands and shell beds or to establish the depositional facies of these beds and the depositional environments that the facies represent (beyond a "beach sand" characterization). Facies modeling is very often an important component of geostatistical reservoir and aquifer characterization that leads to the construction of superior flow models in the absence of tight well control (which is certainly the case here).

My assessment is that the lower marine sediments were probably deposited in shallow waters during the Plio-Pleistocene (5.4 – 1.8 Ma), a period of mild faulting and tilting in Northland. Were the sediments deposited during a marine regression, transgression, or over a regressive/transgressive cycle? What was the provenance of the sediments? What were the depositional environments? How did the basement and topography control deposition? These questions that could all be answered by a standard stratigraphic study of the marine units if core samples were available, and by a comparison with the oldest surficial sediments near Henderson Bay. The answers to these questions would provide important controls on the likely vertical and lateral variations of permeability within the productive aquifer units.

Similarly the ages of the ages of the overlying terrestrial sediments have not been well established. According to the geological map of Isaac (1996) the oldest consolidated dunes are over 70,000 years old. They were formed when sea level was much lower and Aupouri Penisula was much broader. These dunes cannot be underlain by Holocene peat deposits as indicated in the conceptual diagram of Figure 1, but may be underlain by older peats and clay lenses. They also may contain diagenetic iron pans. Holocene peat deposits are prevalent in lower parts of the Aupouri Peninsula and also probably underlie mobile Holocene dunes, all being deposited since about 6500 years before present at which point sea level had risen and stabilized.

The distribution of impermeable peats, clays and pans within the upper terrestrial sequence is poorly characterized, but is highly important as such deposits can limit recharge of the deeper marine sediments, which in turn may allow sea water intrusion along the coast line if wells are overdrawn. Conversely, if these layers do not impede vertical recharge, it would appear that abstraction from deeper units may negatively impact ecologically sensitive wetlands on the peninsula as maintained by the Department of Conservation. The WWLA reports claim an optimality of conditions whereby vertical drainage is sufficent for recharge without saline intrusion but insufficient to cause wetland damage. I do not think that the permeability structure of the aquifer system has been characterized sufficiently well to support this optimistic assessment.

On a related note, avocado orchardists typically break the shallow pan, which raises an additional risk of pesticide, herbicide, and fertilizer contamination of the aquifer, which is not addressed in the WWLA reports.

Nature of aquifer beyond the peninsula shorelines. The nature of the eastern termination of the lower shell beds beneath eastern shorelines is a critical issue that has been inadequately considered in the WWLA report. At Pukenui for example, the shell beds lie 60 m below sea level just a few hundred meters from the water's edge of Houhora Harbour. The shell beds must terminate at some unknown position and depth beneath Houhora Harbour because the entire sedimentary sequence is absent on the western shoreline of the Mt Camel peninsula. As the shell beds are a highly permeable aquifer unit, it is important to know the nature of their eastern termination and the nature of the overlying beds (permeable or impermeable). These factors will control the relative ease of saltwater intrusion if aquifer pressures drop due to water withdrawal further inland. If the shell beds eventually terminate beneath thin sands, sea water intrusion will be easier than if they terminate beneath an impermeable pan or a thick mud layer (for example, filling an ancestral Houhora river valley).

Similar considerations apply to the nature of aquifer system as it extends northeastward from East Beach into Rangaunu Bay. In this case the risk of saline intrusion may be exacerbated by the low elevation of the coastal land.

The aquifer system also certainly extends westward in the subsurface beyond Ninety Mile Beach. I would anticipate based on regional geological considerations (and the natural stagnancy of the lower aquifer from Tritium analysis) that the aquifer deepens and becomes confined further offshore, but this question deserves more attention than it has received in any of the reports.

No detailed consideration has been given to the natural springs that occur near sea level on the western shore of Houhora Harbour (for instance in Lamb's Creek) or along Ninety Mile Beach, or to the possibility that there might be submarine springs fed from deeper parts of the aquifer system (compare HAM3).

The WWLA model terminates vertically at the coast with a sea level head and decreasing conductance with depth (Section 3.1.2), with no attempt to model flow beyond the seashore. The model predicts that about 10% of total recharge volume is discharged below sea level without providing any details of where or how this discharge is occurring.

It seems that it would be valuable to perform an analysis of tidal effects on aquifer pressure (HAM3).

(On a related note, I wondered whether the use of the Ghyben-Herzberg criterion is as conservative as claimed - given the possibility of density-induced saline mixing into a highly permeable unit sitting right above a basement that slopes away from the sea. This is outside my area of expertise, but I searched the subject and it seems that there is quite a bit of recent literature on this topic)

Summary of Subsurface Uncertainties and Recommendations. In summary, the geology of the entire aquifer system is highly heterogeneous and inadequately characterized for the purposes of hydrological modeling. Naïve interpolation between wells using kriging techniques as in the WWLA report is extremely unlikely to produce reliable predictions away from well control.

In my opinion, given the long-term economic importance of the aquifer, it would be prudent for the NRC to commission a thorough scientific study of the Aupouri aquifer before granting further substantial allocations. This study should include an exploratory stratigraphic well program (with coring), supported by geophysical surveys (seismic refraction, gravity, and electrical methods) in areas of critical interest and uncertainty. This would be followed by a thorough structural and stratigraphic characterization. I think that this entire program could be accomplished relatively cheaply, particularly if university research resources were employed. Samples from commercial wells should also be analysed stratigraphically.

Following such a study, hydrologic modeling could be informed by a variety of more sophisticated approaches such as co-kriging and stochastic simulation (standard in petroleum reservoir modeling).

The risk of saline intrusion is quite high and must be guarded against stringently, particularly along the Houhora Harbour coastal strip where communities rely on well water. Because the basement topography and aquifer geology seem to be intricate, a single monitoring well at Houhora is not adequate to protect the water supply of the Houhora-Pukenui communities.

Water balance considerations

The WWLA report states that withdrawals would represent an insignificant proportion of available recharge. I believe that this gives a misleading impression of the aquifer robustness because of the large proportion of recharge volume that will inevitably be "lost" to drains and shallow coastal discharge regardless of deeper abstraction rates. I think that the withdrawal percentage should be denominated by the maximum volume that could possibly be drawn vertically downward the impermeable layers without causing salt-water intrusion. It also seems that any long-term aquifer management plan for the Aupouri Peninsula should include mechanisms to enhance surface water capture in critical areas.

Social, economic, and environmental considerations.

I continue to believe that it was unreasonable to limit input to this consent process to those who already own a well, and to deny a voice to the larger community, including the tangata whenua. It is also unreasonable to ignore the current and future water needs of a growing Far North population, in favor of the current needs of a small number of agriculturalists. It is notable that neither the technical report nor the summary report by NRC includes a discussion of community locations, sizes, and water needs.

I also think that the environmental concerns raised by the Director of Conservation are valid.

Over the 2008-2016 census period population in the Aupouri Peninsula and surrounding areas grew by about 15%. Employment grew by 33%. Agricultural employment accounted for most of this growth, but non-agricultural employment also grew strongly by 25%. There has been a growing population of retirees. While an increase in avocado farming will certainly add to the local economy, it is also true that degradation of the aquifer could result in loss of up to 1300 jobs and possible dislocation of a greater number of people, not to mention loss of future fresh-water dependent economic opportunities.

It is worthy of note that a combination of the existing permitted abstractions together with the proposed abstractions represents 80% of the total limits recommended in the LA2015 report. The total of 1.42×10^6 m^3/y would cost $22M/y at Auckland consumer rates. We should make sure that the Far North community benefits appropriately from the exploitation of this resource and that the natural environment is not degraded.

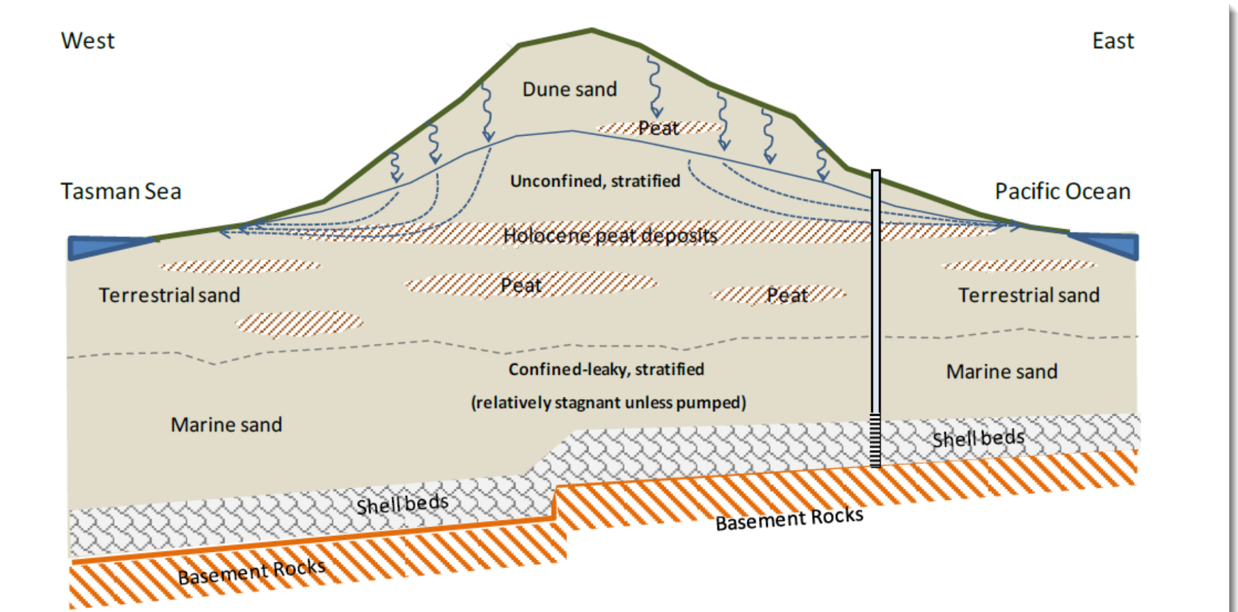

Fig. 1: LA2015

Schematic profile through the Aupouri Aquifer

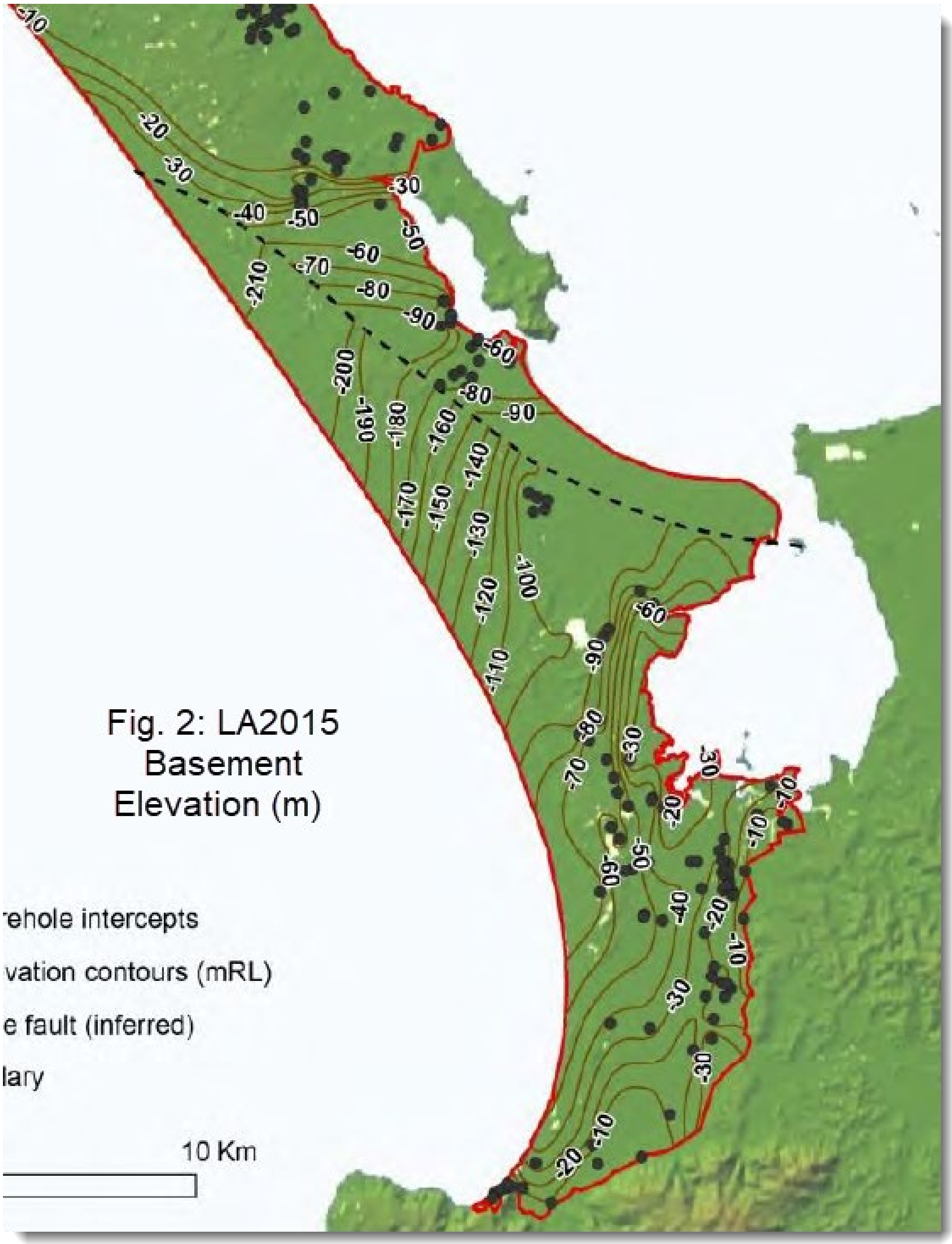

Fig. 2: LA2015 Basement Elevation (m)

Fig.3: WWLA Basement Elevation (m)

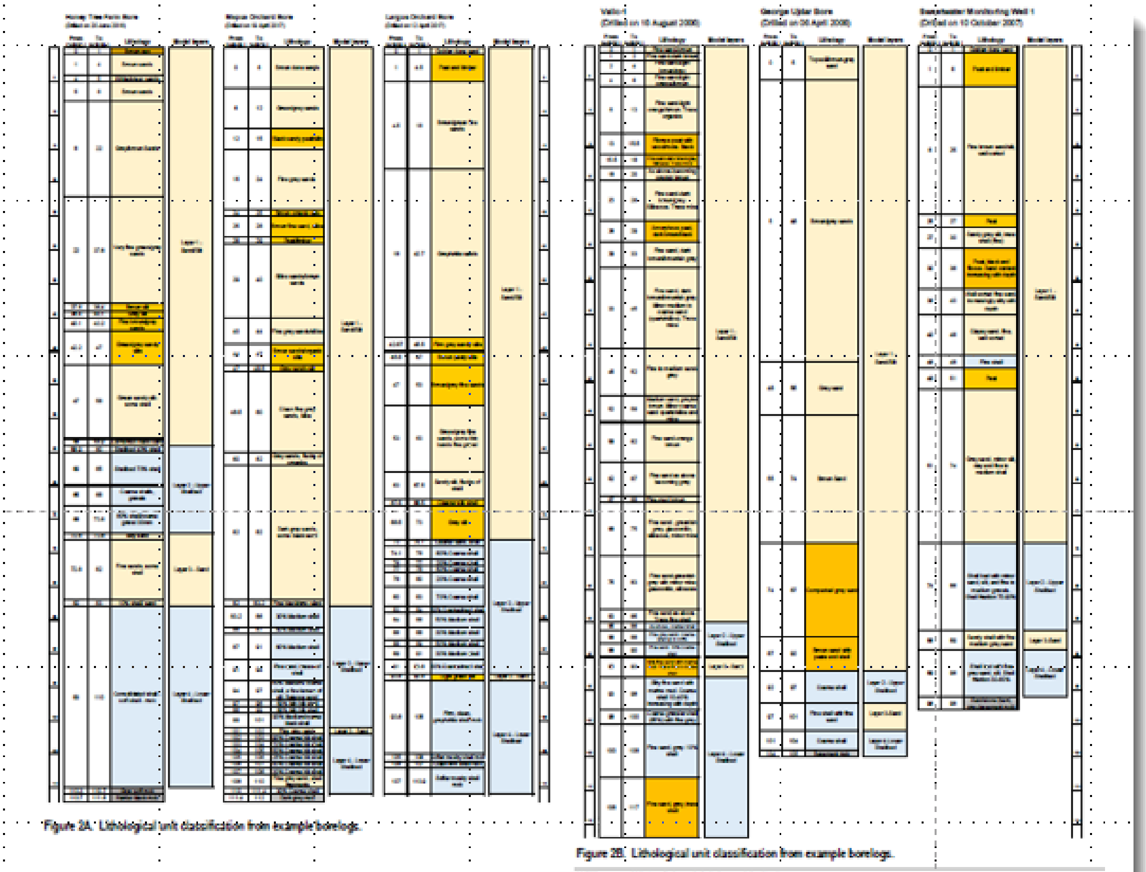

Fig 4: WWLA Well Lithologies