Kawerau Geothermal Field

Annual Community Liaison Group Report

JANUARY – DECEMBER 2017

Table of Contents

1 Introduction

Multiple different companies draw geothermal fluid and energy from the Kawerau geothermal resource. Mercury owns the Kawerau Geothermal Power Station (referred to as KGL) and uses geothermal steam to generate electricity. Ngati Tuwharetoa Geothermal Assets (NTGA) supplies process steam to the Norske Skog Tasman, Carter Holt Harvey Woodproducts, Oji, Sequal Lumber, and Asaleo Care operations for the purposes of paper drying, timber drying, and power generation.

The Kawerau Power Station uses a mixture of geothermal steam and water that is drawn out of the Kawerau geothermal reservoir through a total of 8 current production wells. The Kawerau Power Station is a 'double flash' processing system, which means that it contains two separators: one for separating the high-pressure (HP) steam and the other for separating the low pressure (LP) steam. The high and low pressure steam is passed through the turbine blades, which have different inlets for high and low pressure steam. The steam spins the turbine, which spins the generator, creating electricity.

The spent steam is then sent to a condenser which cools it into water or condensate. The condensate then gets sent to the cooling tower where it is cooled further. From there, a quantity of the water is pumped back into the ground through an injection well, and the rest is recycled back to the condenser to be used as cooling water. All separated water (brine) is piped to injection wells and injected back into the ground.

This report outlines the results of monitoring activities during the 2017 calendar year.

2 Economic Benefits

Geothermal energy has played a role in the development of Kawerau since the 1950s. The opportunities for using this renewable source of energy to generate electricity and provide process steam or direct heat have increased with the introduction of the emission trading scheme (ETS), as geothermal generation produces only a portion of the greenhouse gas emissions produced by fossil fuel generation. Over the year the power stations and process heat supply provide revenue for the local community via the annual rates paid to the Kawerau District Council. The power station employs 16 staff, with many local to the area, and engages local contractors to perform site support services, regular routine maintenance and major maintenance during shutdowns.

By meeting about one-third of residential and industrial electricity demand in the region, the power station provides electricity cost certainty to important local industry (such as the Norske Skog Tasman paper mill) and a platform for other industries to be attracted to the eastern Bay of Plenty. The physical output of the power station is, for the most part, consumed on the local industrial site, where the Norske Skog Tasman, Carter Holt Harvey Woodproducts and Asaleo Care plants are all located, and as a result the electricity losses from transmission of electricity from outside of the Bay of Plenty are eliminated.

3 Fluid Extraction and Injection

KGL abstraction and injection for calendar year 2017 under Mercury (formerly Mighty River Power Ltd) consents 63295 and 67335 have been consistently below the maximum limits stipulated by the resource consents, as shown in.

Mercury consent 63295 states that the quantity of fluid taken is not to exceed 55,000 t/day with an average annual volume not exceeding 45,000 t/day and consent 67335 states that the amount of fluid taken shall not exceed 20,000 t/day. This means that under the two Mercury consents the maximum daily take is 75,000 t/day. Additionally, consent 67355 specifies that at least 77% of the daily geothermal take under this consent will be injected.

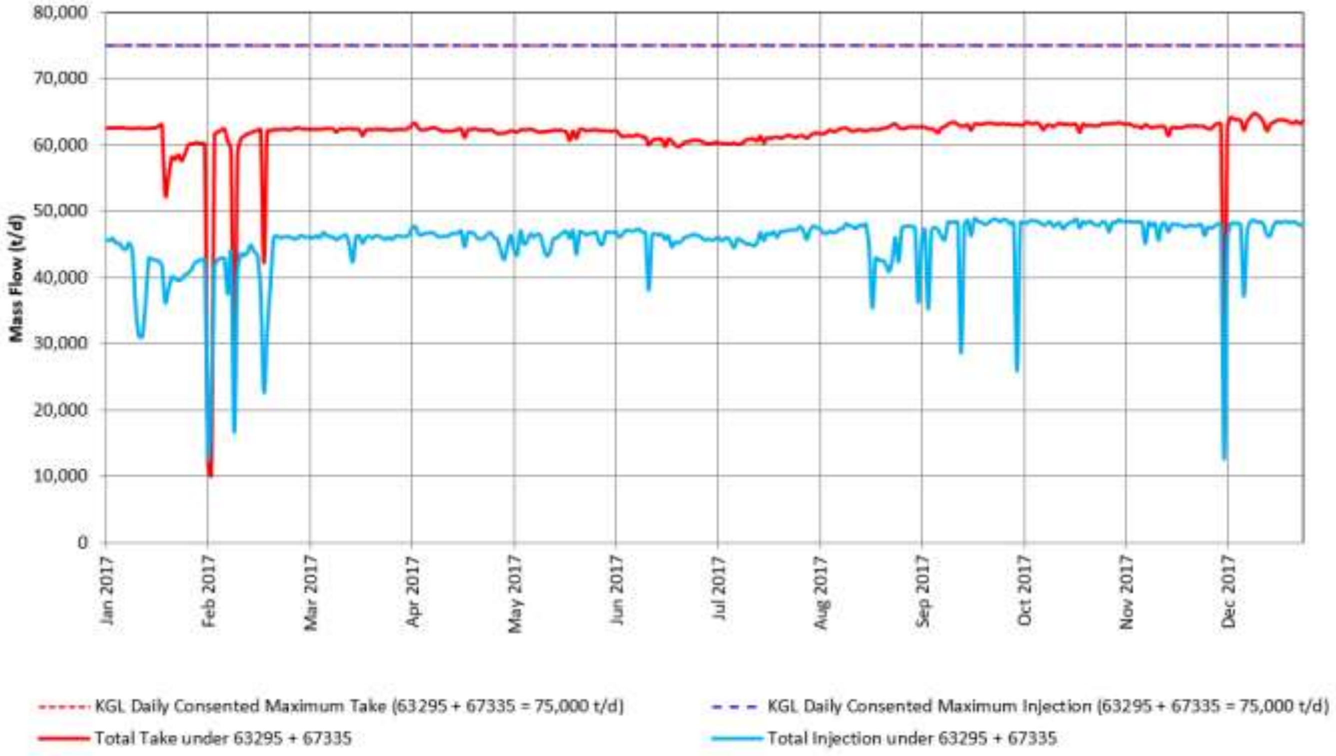

Figure 1. KGL daily fluid take and injection for the 2017 calendar year.

4 Monitoring and Management

To ensure that Mercury operate the Kawerau geothermal system sustainably, efficiently and according to best practice; Mercury is closely monitoring in accordance with Bay of Plenty Regional Council the following:

- Steam and water flows;
- Chemical analysis of extracted resource, injectate, and monitoring wells;
- Geothermal surface feature monitoring;
- Air emissions; and
- Ground levels through benchmark surveying

Results of these monitoring programs are then reviewed by an independent peer review panel on an annual basis, on behalf of Bay of Plenty Regional Council.

4.1 Steam and Water Flows

Mercury operations are based around 8 production wells (1,800-2,800 metres deep) and 7 injection wells (1,900-3,000 metres deep). The performance of the production and injection wells is crucial in sustaining constant operation of the power stations and process heat supply to the mills.

To monitor the well performance, Mercury uses Tracer Flow Tests (TFT) which measures steam and water flow rates while the well is in production. The testing frequency is once every quarter. The results show a similarity in flow rates (mostly showing high flow rates) with respect to bore sizes. The relatively similar high flow rates suggest that the reservoir across the production wells is uniform and has high permeability, indicating good productivity from the resource.

4.2 Well Chemistry

Mercury has carried out fluid sampling from the wells in tandem with flow measurements. Chemistry data is also collected from a number of groundwater monitoring wells situated across the field. This sampling enables the capture of reservoir responses to any changes in extraction and injection, so that a timely response may be performed when required. Data is correlated with any observed changes in the physical characteristics such as flow reduction or cooling, to provide a complete assessment of the reservoir and individual well performance.

The data collected helps in determining reservoir processes that affect field performance and plant generation. This leads to a production and injection strategy which maintains a good balance between production and recharge to the reservoir to ensure the field is managed sustainably.

4.3 Geothermal Surface Features

Natural changes to the surface thermal manifestations at Kawerau have occurred long before any use of the geothermal system for energy production. There has been an overall natural decrease in surface thermal activity since the beginning of the last century.

Chemistry and temperature sampling surveys of two non-flowing thermal pools in the Parimahana Reserve were conducted by GNS Science in February and September 2017. One of these features did not have water (i.e. dry) during the 2017 field visits, hence no water sample was collected. Historical water chemistry data of this feature showed a shift from a dilute chloride-bicarbonate water composition to a more acid-sulfate composition starting 2014 and this also coincided with a 20°C reduction in water temperature. The second feature was also devoid of water during the February field visit but a water sample was collected in September 2017. Similarly, this feature is also showing a more acidic composition over time. Changes in the fluid chemistry of these two features are indicating that the geothermal activity in this area continues to wane. Monitoring of these two pools will continue in 2018.

4.3.1 Ground Temperature

Measured temperatures were obtained at 1 m depth at each corner of two rectangular thermal vegetation plots (A and B) in the Parimahana Reserve (refer to Figure for location). Peg temperatures in 2017 ranged from 57.9°C to 95.3°C for Plot A and from 85.2°C to 99°C for Plot B. Since start of monitoring in 2008, the ground temperature in these two plots has been relatively consistent, with the fluctuations within the range of natural variation that is expected for thermal ground.

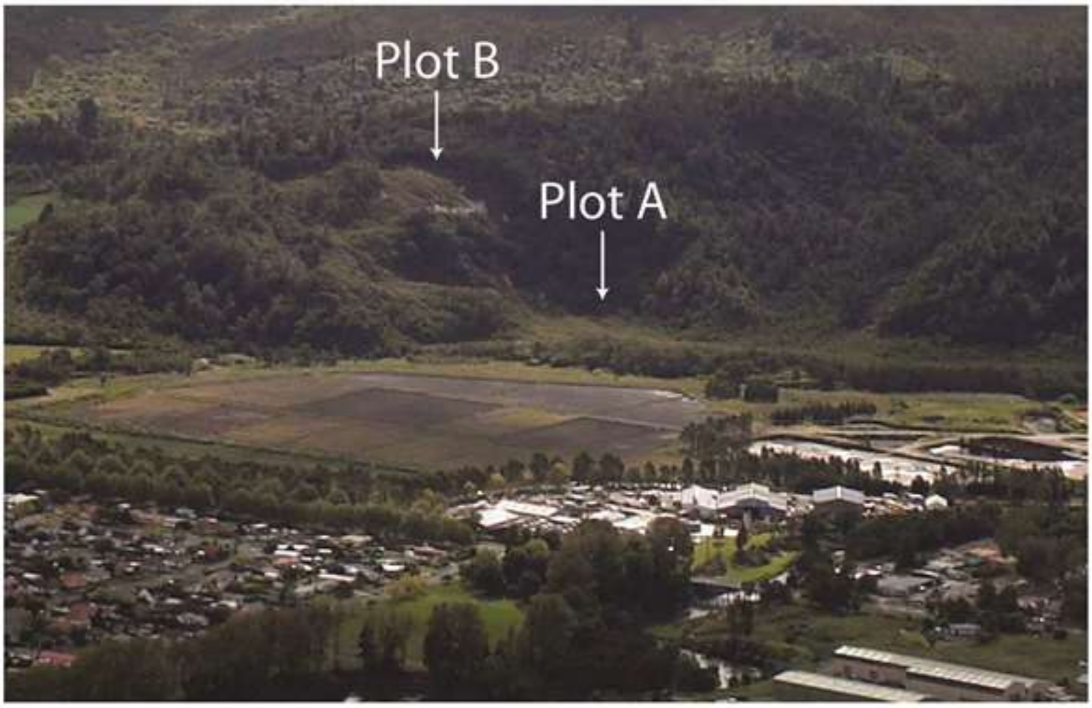

Figure 2: Parimahana Reserve geothermal vegetation and ground temperature monitoring locations.

4.4 Air Emissions

While utilising a renewable energy resource, geothermal operations do discharge a variety of gases to the atmosphere.

Emissions of H_2S and CO_2 for Mercury resulting from geothermal operations are shown in **Error! Reference source not found.**. The gas emission levels have reduced since the commissioning of KGL and are showing signs of stabilisation. The variation in the concentration of the gases is due to changes in the natural gas flux concentration within the geothermal reservoir as fluid is extracted. In 2017, the average amount of H_2S emitted was 347 kg/hr. The Greenhouse Gas (GHG) unique emission factor averaged 0.0173 tCO2-e/tsteam in 2017.

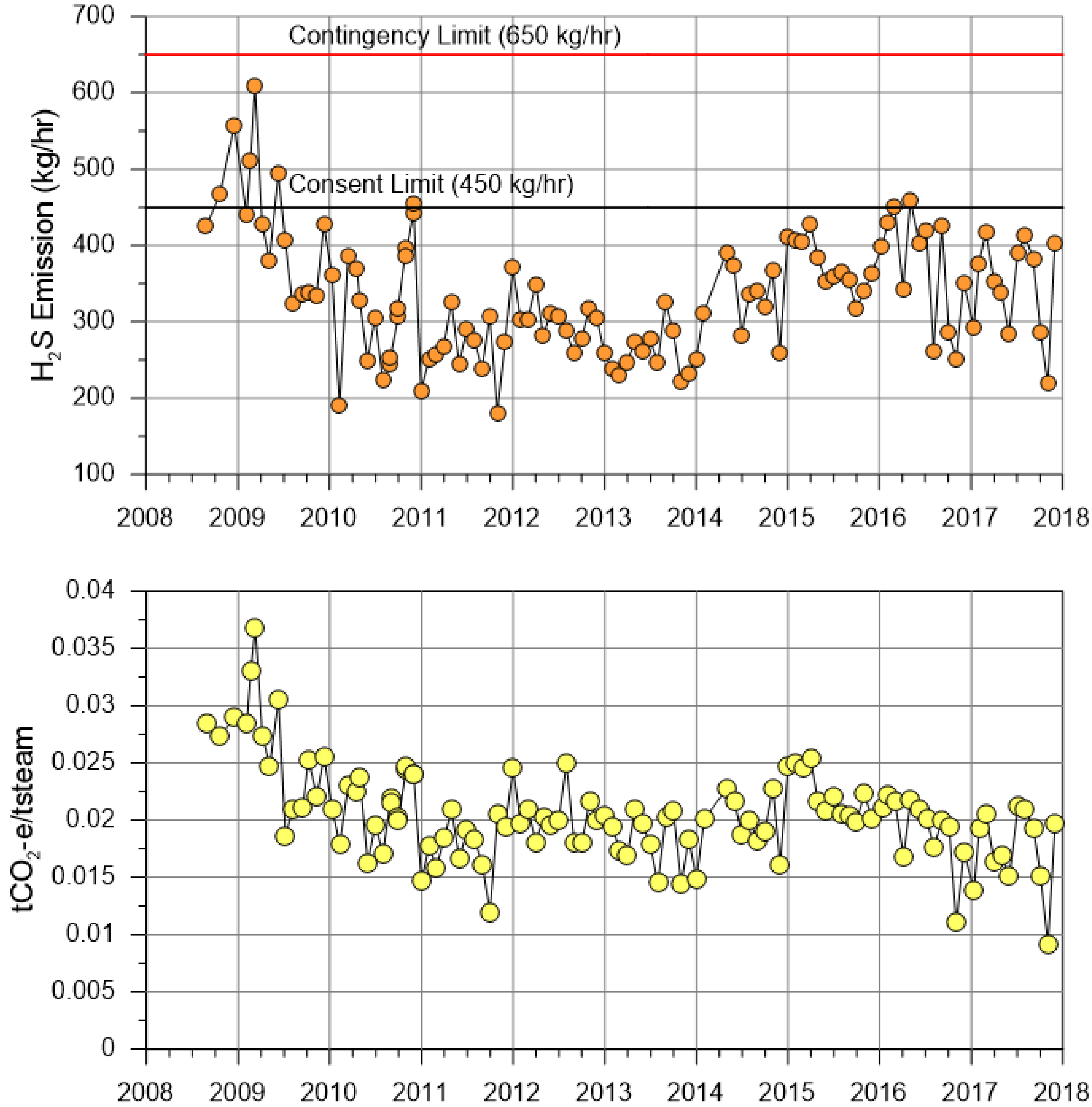

Figure 3. KGL Hydrogen Sulphide (H2S) and Greenhouse gas (GHG) emission in tCO2-e/t steam.

4.5 Precision Ground Levelling Surveys

A subsidence levelling survey was undertaken by Energy Surveys Ltd in September 2017 covering some 36 km^2 of the Kawerau geothermal monitoring network with 648 benchmarks (BM's) surveyed. The 2017 survey covered most of the area surveyed in August 2016.

Total subsidence at seven representative benchmarks is shown in Figure 4. The areas where maximum subsidence occurs form small localised subsidence features that had been identified as early as the 1970s, although a new area of subsidence near to the west of the industrial estate was identified in the August 2016 survey. Generally, these areas have shown steady decline in subsidence rates in the last 2-3 years while the newly identified area to the west of the industrial estate showed an increase in subsidence and has the maximum measured field subsidence for the 2016-2017 period (78mm/yr). These localised subsidence features are generally thought to be a very shallow phenomenon related to the compaction of old river channels and terraces and independent of deep geothermal fluid operations although the new subsidence area to the west of the industrial estate is probably related to the cooling in the vicinity. Away from these localised subsidence features the subsidence rates are much lower being on the order of 0-20 mm/year.

The historical and anticipated subsidence rates at Kawerau are not large, nor are they uncommon for geothermal operations. The annual subsidence rate at Kawerau is much lower than that seen at other geothermal field such as Wairakei and Ohaaki, which are in the order of 200 mm/year. The relatively low subsidence rate at Kawerau is likely related to the small pressure declines seen in the field to date, and predicated in the numerical model.

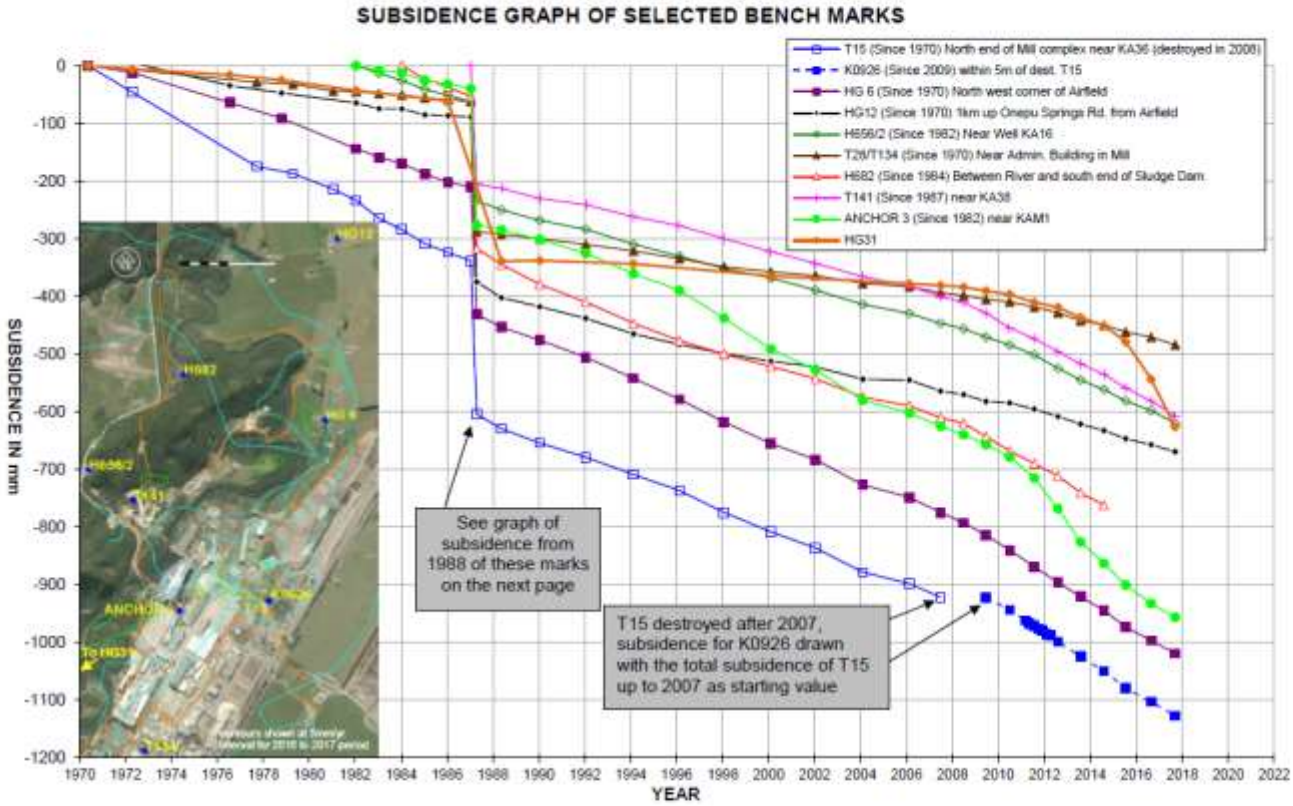

Figure 4: Subsidence on the Kawerau Geothermal Reservoir since 1970. Note that the sharp drop in 1987 is the effect of the Edgecumbe earthquake. (Kawerau Levelling Report, 2017)

4.6 Reservoir Model

Mercury maintains a geothermal reservoir simulation computer model to help manage the Kawerau geothermal system in a sustainable manner. This model helps simulate physical changes in the Kawerau geothermal system as a result of the extraction and injection of geothermal fluids. It uses temperature and pressure measurements from wells, geological observations and geophysical information collected over time. In 2017, the “Holt Model” was the official model of the field for the purpose of scenario forecasting. Although the Holt model generally obtains a reasonable match to most measured field data, it has not been updated for several years. During the reporting period, an application was submitted to BOPRC to replace the approved numerical model with Kawerau Reservoir Model v3 (KRMv3), a new model that takes into account an updated reservoir conceptual model and is calibrated to updated field data. At the time of writing, this application has been approved, and the new field model will be used for forecasting in future reporting periods.