WHAT MAKES GEOTHERMAL FEATURES SIGNIFICANT? CHALLENGES IN INTERPRETING AND APPLYING ASSESSMENT CRITERIA

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ABSTRACT

Geothermal surface features and the deeper resource support growing and renewable energy uses and tourism. The two ends of this usage spectrum create a unique role for geothermal surface features, being the focus of one and under threat from the other. They contribute culturally, economically and environmentally to the well-being of communities and support both tourism and energy industries.

The management of surface geothermal features is not without its challenges. Resource managers need to consider carefully the values requiring protection in the face of competing use demands, to provide certainty for all users.

The Bay of Plenty Regional Council (BoPRC) has under the Resource Management Act 1991 (RMA) developed a policy approach that accommodates the demand for use of the geothermal resource and the need to protect surface geothermal features. The policy requires identification of “significant geothermal features” (SGFs) using consistent criteria, therefore ensuring their protection through policies and rules in Regional and District plans.

While the criteria for the assessment of “significance” are established and set in the Bay of Plenty Regional Policy Statement (RPS) (BoPRC 2014), there is currently no agreed methodology to interpret and apply them consistently and transparently. As such no ‘complete’ schedule of SGFs has been developed in the Bay of Plenty Region, and this creates risks to vulnerable features as well as uncertainty for potential resource users.

Although ‘significance’ assessments are common under the RMA for ecological (including geothermal vegetation) and landscape values, the detailed assessment of multiple significance criterion for different geothermal feature types, has not been established in the same manner. The application of significance testing or ranking of surface geothermal features, is relatively new and untested.

At the request of BoPRC, GNS Science have interpreted the RPS criterion in the context of the Bay of Plenty Region, and also the wider Taupō Volcanic Zone and developed methodological options for criteria assessment (Scott and Bromley 2017). A preferred methodology has been selected by BoPRC and piloted by GNS Science. Results from this pilot are promising and show that the methodology developed is workable as a means of applying the RPS criteria. In this presentation we will share aspects of this process.

1. INTRODUCTION

Geothermal activity supports a growing and renewable economy and our unique geothermal surface features play an important role in this. They contribute culturally, economically and environmentally to the well-being of communities and support a thriving tourism industry. Similarly, direct heat use and geothermal electricity generation can contribute significant economic benefits at a local, regional and national level.

Managing geothermal systems to balance development with environmental protection is not without its challenges. Resource managers need to consider carefully the values requiring protection in the face of competing use demands, to provide certainty for all users.

The Bay of Plenty Regional Council (BoPRC) has, under the Resource Management Act 1991 (RMA), developed a policy approach that accommodates the demand for the use of the geothermal resource and the need to protect surface geothermal features. The policy requires the BoPRC to identify “Significant Geothermal Features” (SGF’s) using consistent criteria, therefore ensuring their protection through policies and rules in Regional and District plans.

While the criteria for the assessment of “significance” are established and set in the Bay of Plenty Regional Policy Statement (RPS) (BoPRC 2014), there is currently no agreed methodology to interpret and apply them consistently and transparently. This paper discusses a potential methodology to assess SGF’s based on the criterial in the RPS.

2. POLICY CONTEXT

In New Zealand, the principal statute by which geothermal resources are managed is the RMA. The overriding purpose of which (Section 5) is to promote the sustainable management of natural and physical resources. Matters of national importance as set out in Section 6 must also be recognised and provided for.

The underpinning concept of sustainable management within the RMA allows for use and development of resources provided environmental effects are appropriately managed. For geothermal resources regional and district councils are required to exercise functions and responsibilities to achieve this. It is not appropriate for councils to take a position that requires the complete protection of all geothermal surface features and ecologies at the expense of extractive use and vice versa. A sustainable management approach under the RMA requires that effects are considered in relation to the overall purpose of the RMA (Section 5) whilst at the same time recognising and providing for those considered a matter of national importance (Section 6).

In simple terms, section 6 identifies multiple matters of national importance and contains thresholds of importance using terms such as outstanding and significant. Such matters are typically assessed through the application of various criteria sets.

Given their uniqueness and relative rarity, Section 6 is of particular relevance for council when considering the management of geothermal surface features.

2.1 Regional Policy Direction

The BoPRC's Operative RPS provides a framework for sustainably managing the region's natural and physical resources. It highlights regionally significant issues and sets out what needs to be achieved (objectives) and how it will be achieved (policies and methods).

For geothermal, the RPS accommodates the demand for use of the resource and the need to protect surface geothermal features. The framework provides for the range of different values associated with geothermal on a regional basis rather than trying to accommodate all values within all systems. It sets out a region wide group classification approach by establishing different management purposes for different geothermal systems e.g. the extractive use of the resource is confined to some systems, while other systems are protected for their intrinsic values.

The RPS definition of a Geothermal system is - a system defined by scientific investigation comprising geothermal energy stored as geothermal water or steam and the rocks confining them and associated water, steam and gas emissions and the geothermal surface features resulting from these emissions and is believed to have no hydrological connection to another system.

The six geothermal management groups are as follows:

Group 1 – Protected Systems

Group 2 – Rotorua System

Group 3 – Conditional development systems

Group 4 – Development systems

Group 5 – Low temperature systems

Group 6 – Research systems

The policy direction for each of these management groups sets out the level of effects management that must be delivered. For example, in a system such as Rotorua any use of the resource must avoid, remedy or mitigate effects to surface features while in the Kawerau system any adverse effects need only be remedied or mitigated and only for those features identified to be significant.

2.1.1 Significant geothermal features

The RPS contains a number of policies and methods where establishing the significance of geothermal surface features and providing for their management is a matter for consideration.

The presence or otherwise of SGFs has important implications for the use and development of geothermal resources in the region. Perhaps most notably that the management group a geothermal system sits within is in part determined by the presence of SGFs.

The RPS requires the identification of "SGFs" using consistent criteria applied by qualified, experienced geothermal specialists, and their protection through policies and rules in regional and district plans.

Although 'significance' assessments are common under the RMA for ecological (including geothermal vegetation) and landscape values, and have been undertaken for many matters in the Bay of Plenty Region, the detailed assessment of multiple geological criterion for different geothermal feature types, on a site by site basis, is less common.

Additionally, unlike landscape features which are locally uncommon, but become more common at a national level, geothermal surface features and ecologies are the reverse (locally common and nationally rare). This relative rarity is the primary reason that assessment criteria typically used to determine significance, such as for other RMA section 6 matters, are not fit for purpose for geothermal features. The criteria would capture all of them.

A specific criteria set was developed and included within the RPS in response to this issue (RPS appendix F set 7). The Set 7 criteria is consistent in how it addresses geothermal feature assessment as per other Section 6 matters in that it has remained as a high level narrative. However, statements relevant to geothermal assessments have been rephrased to reflect the unique context and spatial distribution of geothermal features.

While the criteria for the assessment of "significance" are established and set in the RPS, there was no agreed methodology to interpret and apply them consistently and transparently. As such no 'complete' schedule of SGFs has been identified in the Bay of Plenty Region. This creates risks to vulnerable features as well as uncertainty for potential resource users. Added to which, a crucial part of assessing criteria is the identification of why something is important, the elements that make it special. This information can be used as the tool to assess and understand the effects from use against what is being sought to be protected e.g. when considering applications for consents.

2. BACKGROUND

Assessing the effects of development on geothermal surface features and ensuring "important" geothermal features are preserved has been documented since 1978 (Houghton et al. 1980). A range of simple to complex methods of assessing and/or ranking surface geothermal features for importance from an environmental perspective is summarised in Scott and Bromley (2017). Key to most of the assessments is firstly identifying the type of geothermal features that need to be considered. The RPS identifies 12 geothermal surface feature types (Figure 1) that need to be considered in any SGF assessment. These categories are high-level, and primarily focus on active geothermal features. This high-level approach to the categorisation can sometimes result in ambiguous feature type assignments (e.g. springs that have intermittent flows could either be categorised as a spring or a pool depending on if the feature was flowing at the time of the assessment).

Table 15 - Geothermal features : main types and associated habitats				
Discharge energy High	1. Geysers	4. Intermittent or active hydrothermal eruption craters	7. Mud geysers	10. Fumaroles
↕	2. Flowing springs	5. Mixed springs	8. Ejecting mud pots	11. Steaming ground
Low	3. Non flowing pools	6. Mixed pools	9. Mud pools	12. Heated ground
	Primary geothermal fluid	*Mixed/diluted geothermal fluid*	*Mixed/diluted steam heated fluid*	*Steam Fed*
Geothermally-influenced aquatic habitat				
Geothermal habitat on heated/acid dry ground				
Habitat dependent on geothermally-altered atmosphere overlays all types (warm air, frost-free)				

Figure 1: A schematic representation of surface geothermal features (BoPRC 2014, based on Scott 2012)

The RPS defines 11 criteria (with a basic definition) for which geothermal surface features must be assessed against for significance:

- Natural science
  - *Representativeness, diversity and pattern, rarity, distinctiveness*, resilience, vulnerability.
- Aesthetic values
  - Memorability, naturalness, transient values.
- Associative values
  - Shared and recognised values, Māori values.

The categories in *italics* make specific reference to how surface geothermal features compare to other geothermal features in the Taupō Volcanic Zone.

This paper only considers an assessment of SGF's based on the natural science and aesthetic values.

3. METHOD OF RANKING SGF'S

Definitions of the RPS criteria are extended (with examples) by Scott and Bromley (2018) to provide guidance to assessors for the interpretation of each criterion. The natural science factors cover how representative or distinctive a feature may be, along with its diversity or rareness. Also included are the resilience or vulnerability of the feature to natural and induced change. These are related to how a feature is recorded and catalogued (Scott 2012) and the physical processes that control the type and level of activity.

The aesthetic values are related to the perception and/or appreciation of the values or principles the community associates with a surface feature, via how memorable or natural the feature appears. It also considers, from an aesthetic point of view, the natural transient characteristics of some surface geothermal features.

A numerical ranking system is proposed (Tables 1 and 2) with weighted scores for each criterion summed for each surface geothermal feature. This results in a single number that can be used to test for significance (a higher number means the feature is "more significant"). Weighted scores are proposed because:

- The natural science factors are considered to provide a more representative assessment of significance than the aesthetic values (66.6% and 33.3% of the total score respectively).
- Rarity and vulnerability are considered more important than the other factors in the natural science factors, resulting in a weighting regime of:
  - Representativeness – worth 15% of the natural science factors score.
  - Diversity and pattern – worth 15% of the natural science factors score.
  - Rarity – worth 20% of the natural science factors score.
  - Distinctiveness – worth 15% of the natural science factors score.
  - Resilience – worth 15% of the natural science factors score.
  - Vulnerability – worth 20% of the natural science factors score.
- Naturalness is considered more important than the other values in the aesthetic values, resulting in a weighting regime of:
  - Memorability – worth 25% of the Aesthetic Values score.
  - Naturalness – worth 50% of the Aesthetic Values score.
  - Transient values – worth 25% of the Aesthetic Values score.

Table 1: Guidance qualifiers for the Natural Science Factors. TVZ = Taupo Volcanic Zone.

Level	Feature Descriptor	Representativeness, Diversity, Distinctiveness	Resilience	Vulnerability and Rarity
1	Inferior	Common feature, poor example with few attributes of significance	Not very resilient to natural change	Commonly affected and vulnerable
2	Common	An imperfect feature type, showing some attributes of significance	Weakly resilient to natural change	Abundant feature, weakly affected with some vulnerability
3	Typical	Typical feature type, with significance	Resilient to natural change	Common feature with normal resilience
4	High Quality	A distinctive and quality feature type with significance	Highly resilient to natural change	Rare feature, with some susceptibility
5	Exceptional	Exceptional TVZ example showing supremacy of type significance	Strongly resilient to natural change	Very rare, robust and unaffected by external forces

Table 2: Guidance qualifiers for the Aesthetic Values.

Level	Descriptor	Memorability and Transient	Naturalness
1	Insignificant	Few attributes of feature significance	Totally impacted and compromised, not natural
2	Low notability	Poor geothermal feature, displays some aesthetic feature attributes	Slightly natural, very high level of impact
3	Typical	Typical geothermal feature, possesses most aesthetic feature attributes.	Moderately natural with high level of impact and compromising

Table 3: List of the weighted scores for the four assessors and related statistics (after Scott and Bromley 2018).

Feature	A #1	A #2	A #3	A #4	Mean	Max	Min	Range
Geyser: Pohutu	4.6	4.5	5.0	4.6	4.7	5.0	4.5	0.5
Geyser: Crater Bay Lake Rotomahana	4.6	4.5	4.5	4.6	4.5	4.6	4.5	0.1
Flowing spring: Parekohoru	3.6	3.4	4.4	3.6	3.8	4.4	3.4	1.0
Flowing spring: Soda Spring	3.4	3.0	3.7	3.4	3.4	3.7	3.0	0.7
Non Flowing spring: Korotiotio	3.6	3.5	4.5	3.6	3.9	4.5	3.5	1.0
Non Flowing spring: Rachel Pool	3.0	2.5	4.5	3.0	3.3	4.5	2.5	2.0
Mixed spring: Lake Roto-a-tamaheke	3.6	4.0	3.9	3.6	3.8	4.0	3.6	0.4
Mixed spring: Frying Pan Lake	4.2	4.6	4.1	4.2	4.3	4.6	4.1	0.5
Mixed pool: RRF2051 (Arikikapakapa)	2.4	2.6		2.4	2.0	3.1	2.4	0.6
Mud Geyser: Te Kopia Road	3.9	4.3	4.0	3.9	4.1	4.3	3.9	0.4
Ejecting Mud Pot: Waiotapu Loop Road	3.2	3.2	3.2	3.2	3.3	3.5	3.2	0.4
Mud Pool: RRF2112 (Arikikapakapa)	2.1	2.5	2.1	2.1	2.3	2.5	2.1	0.4
Fumarole: Fumarole 0, Whakaari	4.2	4.2	4.3	4.2	4.2	4.3	4.2	0.2
Steaming ground: KAF3001 (Kawerau, sports centre)	2.2	2.6	2.2	2.2	2.4	2.6	2.2	0.4
Heated ground: Sulphur Flats - Rotorua	3.1	3.3	3.1	3.1	3.2	3.4	3.1	0.4
Heated ground: Outlet of Frying Pan Lake, Waimangu	1.7	2.2	1.7	1.7	2.0	2.6	1.7	0.9

4. METHODOLOGY TESTING

Sixteen surface geothermal features from the Geothermal Surface Features Database (8 April 2018) are used in this example. Four assessors experienced with surface geothermal features in New Zealand were used and applied the numerical and weightings as discussed above. Table 3 summarises the results of the assessments for the four assessors. Although there is some variability in the scores as might be expected, Table 3 shows that the scores are relatively consistent.

5. DISCUSSION

The preferred method which is tested and reported here has provided a consistent and transparent approach to ranking surface geothermal features. The features containing primary geothermal fluids that sit on or lie across the boundary of 'springs or pool' provided the most inconsistency in this testing. We also noted:

- In order to compare geothermal surface features on a Taupo Volcanic Zone scale (as required by the RPS for several of the natural science factors), a database of geothermal surface features in a consistent format needs to exist and be maintained.

- Natural resource scientists experienced with New Zealand geothermal surface features are required to apply this method.

Note in this study the following are not addressed:

- We do not define the score at which a feature is defined to be "Significant". Environmental managers will need to decide what score, or, range of scores will be used to trigger regulatory or rules that may apply.

- We do not consider associative values in this assessment as required by the RPS. These factors may significantly affect the significance ranking of a surface geothermal feature compared to the result obtained by this assessment alone.

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