1. ABSTRACT
The eco-structural composition technique uses natural and organic sound source materials at the beginning of a composition project with the intention of imbuing composed music with a natural or organic structure. This paper will describe a case study exploration of an eco-structural musical work and the process of composing it, from the source material to the finished work. The paper concludes by discussing the effectiveness of the process and how it could be improved for future musical compositions.

2. INTRODUCTION
*Flow* is a musical piece written by Tim Opie in 2009, shortly after the Black Saturday Bushfires in Victoria. For months the land had been getting very dry. On Black Saturday the temperature rose to 47°C in some areas. Reports were coming in on the radio of fires near the composer’s home and a decision had to be made, either to evacuate or prepare to fight the fire. He and his family chose to stay. Fortunately the fire didn’t come too near the house. The plants around the house had all dried and withered, including the normally lush green fire retardant agapanthus. The waterfall and stream that ran through the national park near the house had also dried up. However about two weeks later it started to rain.

With the rain came relief. The waterfall again began to flow. Although it was not much more than a trickle, seeing the waterfall again in action was inspiration enough to get out recording equipment and begin work on a new composition.

This paper will briefly review eco-structuralism, the compositional technique used to create the musical work, and then examine the source materials, the eco-structural analysis performed on them, the processes applied to the resulting data, and, the compositional arrangement of the work. Finally the paper will discuss insights arising from eco-structuralism in practice, and explore ideas that may further the creative use of eco-structuralism.

3. ECO-STRUCTURALISM
Eco-structuralism is a composition technique whereby the composer uses the analysis of recordings of natural and organic sounds to dictate structure and other musical events within a composition (Opie & Brown 2006). This compositional technique is founded on the concepts of soundscape composition (Schafer 1993) and eco-composition (Keller 2006). It also, unlike these techniques, uses a formalised approach to achieve its outcome reminiscent of some twentieth century compositional approaches (Schoenberg 1975, Xenakis 1971).

When using eco-structuralism, the composer firstly chooses their source material, then using eco-structural analysis software they generate XML data files that detail various sonic attributes of the recording. Those attributes include amplitude, fundamental frequency, timbre and space. The data files are then used within a rule-set for composition. The rule-set defines strict use of the data, the intention of the strict rules being to maintain the integrity of the original sound recording structure, whilst still allowing for creative musical decisions.
The next section describes the how eco-structuralism was employed in the creation of the work, *Flow*.

4. RECORDING AND COMPOSING

At the time of the bush fire event that inspired the composition of *Flow*, only a standard definition video camera was available for audio capture. The audio was set to the highest quality available, which was a non-compressed 16bit, 44.1khz mono sound file, recorded through the built in microphone. About an hour of footage was captured whilst walking along the bank of the stream, and sitting up at the top of the waterfall.

A decision was made early on to only use audio from the excerpts of that video. After the filming process the footage was reviewed and sections selected. This was a purely aesthetic decision based primarily on the clarity and subject of the audio, but with some concern as to the clarity and subject of the video. Elements were selected that were interesting both sonically and visually. Seven clips were chosen, representing various parts of the waterfall and stream. The audio was extracted from these clips and the visual elements of the film were used to create a visual narrative, without being distracted by sonic considerations at that point.

Then began the audio analysis process. Having already extracted the audio from the clips, it was a simple matter of running these files through the eco-structural analysis software. An important feature of the eco-structural audio analysis process is the ability to add extra information to the resulting XML files as part of the analysis process. The extra information is identifier meta-data that allows anyone to find out exactly when the recording was made, the site of the recording, a geographical location for easy geotagging, and a description of the events around the recording. This meta-data proved to be extremely useful when reviewing eco-structure XML files, as it instantly reminds one of the recording, including events that may have been forgotten.

For example the file flow1-amp.xml stated:

**Date of Recording:** Saturday 21 February 2009

**Description of Audio:** Section 1 of the audio extracted from the waterfall near The Basin. The Basin waterfall is almost dried up due to the ongoing drought in Australia. Filmed two weeks after Black Saturday. There had been some ash falling in the area a few nights previously, but today has been quite a good, and substantially cooler day, having had a tiny amount of rain the night before, just enough to produce flow. There is an almost white noise tone to the piece, due to the speed the water is travelling, but there is a much louder trickle sound, which is fluctuating in frequency

**Location of Recording:** Waterfall in the Dandenong Ranges National Park, near The Basin

**Geographical Location:** 37d 51 58.80 S 145d 19 49.00 E

As an ecological endeavour, this descriptive information is useful not only as a contextual reminder or cataloguing system, but also as a historical marker of sound events of that location at that moment in time. The composer is strongly encouraged to include this information when working with eco-structuralism. R. Murray Schafer discussed the importance of the sound event, in which the place and time are critical in understanding the context of the sound from which it was taken, as no sound event will be identical (Schafer 1993).

The rest of the information in the resulting XML file pertains specifically to the audio, and is generated automatically.

When viewing the XML audio analysis data in a graphic form (see figure 1), and comparing it to the original sound (see figure 2), coinciding peaks can be easily identified, indicating that the data is correlated (Opie 2005).
5. ANALYSIS OF FLOW

In Schoenberg’s (1967) Fundamentals of Musical Composition, he gave advice for self-criticism. Although this advice was written for more traditional music, it can be easily modified to critique other musical forms. We have chosen to use a modified version of this form of critique for the analysis of Flow in section 5.1, as well as formulating a series of questions that critique eco-structuralist intention in particular as outlined in section 5.2.

5.1 Musical Analysis and Critique

Listen for stylistic coherency: Is the music well constructed? Does it accomplish the composer’s intention? Is there a teleological coherency throughout the work?

Whilst not having any traditional sense of melody, this piece does however have a strong motif that is integral to the piece. The water flowing motif keeps reappearing in various transformations. There is a constant sense of movement, as if the piece is trying to reach a particular goal, although there are certain points where the piece slows down to for a breath, which is a welcome break for the audience.

Analyse motivic development: How do parts in the music lead to the unfolding of new events?

The very first motif begins sounding very much like the original sound source, but undergoes a slow transformation, which seems at first to sound more metallic, but eventually becomes more bouncy. This idea follows a composition characteristic noted by Barry Truax (1994) in regard to stretching sound:

By keeping the attack portion relatively intact and stretching only the body of the sound, each signal retained its recognizability, but allowed listening associations to be savoured, along with the inherent musicality of its constituent harmonics (Truax 1995).

By preserving the initial attack of the sound source before it is heavily affected, helps invite the listener into the music that is about to unfold.

During the middle section of Flow the sound undergoes much more radical transformations. This happens through a slower unfolding of transformations. The texture is also denser. It sounds as if there are many voices speaking from the water.

The end section involves a slowing down of events. The texture thins out and becomes less transformed. In some parts the sound almost slows to a silence. This is comparable to the...
waterway in which this was filmed. Initially the stream is peaceful and placid, but as it gets closer to the rapids and waterfall it speeds up and gets louder, but after reaching the bottom of the fall is disperses much more slowly and begins to stagnate and divide into small slow moving bodies of water.

Eliminate non-essentials but avoid monotony: What is the balance of simplicity and complexity? Is there an overload of textures or tones? Is there enough interest in the material?

In the first draft of this piece more source materials were used, however it quickly became apparent that there was too much going on. It was becoming saturated to the extent that one sound could not be discerned from another. It was decided to strip the materials back to just four sound sources, as if it were an SATB choir. This simpler structure allowed more reflection on the intricacies of the composition and the works temporal structure.

Within this simpler framework, there was still sufficient timbral variety and variations in form to give the piece sufficient interest.

Countermelodic Construction: Does the interaction between parts add interest, vitality and direction to the musical work?

Special attention was paid to using a broad range of timbres and frequencies overall, but with particular focuses at certain times. There are low parts throughout the piece that give good balance and depth. During the latter part of the piece, the low parts take the thematic role for a short while, whilst the higher parts fade out. The “bass line” definitely adds variety and vitality to the piece, and helps move the piece forward, over the waterfall.

5.2 Eco-structural Analysis and Critique

Aesthetic Significance or Affordance of the Sound Source: What signifiers are present that can be used in a compositional manner?

Sound source 1 consists of two strong sounds. In the foreground is the sound of trickling water. It is very soft and fluttery, with constantly moving pitches. In the not too distant background is the sound of rapidly moving water, sounding more like white noise and almost drowning out the foreground sound. This background noise is actually the soundmark of the area whenever the waterfall is flowing. Locals use it to locate the waterfall whenever they go bushwalking in the area. To get home, you just need to find the river and follow the flow of the water until it reaches the back of the houses. During non-drought seasons the waterfall is so loud that you need to shout to communicate when you are nearby. This sound also provides two strong frequency bands as can be seen in its spectrum shown in figure 3.

Sound source 2 contains the sound of water flowing through rocks into a deeper pool. The recording is made at a very intimate level to the point at which the water is hitting the pool. The background noise is much lower in amplitude. The spectrograph of this sound, shown in figure 4, indicates that there are some distinct harmonics present in this recording. These harmonic levels could be used in the timbre study (Opie 2008) to dictate some kind of harmonic ratio that could be implemented within the composition.

Sound source 3 has similarities to a running tap. It is a small, but strong flow of water dropping into a small pool of water. Interestingly, the spectrogram indicates a wider spread in frequency than I expected. The
spectrum of this recording has more randomly distributed elements, as seen in figure 5, although when listening to the sound, it does not seem so unpredictable but sounds like a thematic return to a particular frequency. Such a part might make a good melody or perhaps countermelody.

Figure 5: Spectrogram of source sound three.

Sound source 4 is a small trickling sound that was recorded further away from the waterfall, such that the background noise from the waterfall is barely audible. The simplicity of this audio recording allowed it to work well as a kind of melody line. In figure 6 we can see a distinct lower frequency range with a harmonic band above it.

Figure 6: Spectrogram of source sound four.

Structural Integrity Post Transformation:
How has the transformed material maintained or gained useful sonic organisation?

The structure of the first motif is quite evident. It begins by sounding identical to the source, however, it is undergoing a slow transformation that is stretching the structure. The stretch is so

minute that at first it is not noticeable.
The middle section seems to be least like the original sound source, however, there are still many tell-tale signs that it is from the same source. We hear the transformation because it is created as an evolution, becoming more radical with each transformation.
The ending sounds more like the original sound sources, so the structural content here is more easily identified, as it was in the beginning.

When comparing the spectrograms of the initial sound sources to the final piece in figure 7, we can see where some of the sound sources have been implemented. For example sound source 4 is evident in the first section, and sound source three is used in the last third, with sound source one mixed in. The second part in the piece was influenced by sound source two.

Aesthetic Outcomes: What is the character of the transformed material?
The sounds of nature through the structures of filed recordings have been blended in a very tight manner in this work. When creating new sounds from the structural data, the original recordings were again reused as the sound source, so that events such as structural elongation would match in a very precise manner. Also events such as amplitude enveloping and frequency filtering were applied to the original sound in order to emphasise significant events within those recordings.

Although some sections have a very ‘digital’ sound, they are just highly transformed sound recordings from the same source. Blending the analyzed structure data back with the original sound source trough transformation mappings

Figure 7: Spectrogram of Flow
highlights the sonic signifiers, as well as the cultural identifiers. This process also amplifies the motion and change inherent in the original sound source. Interestingly, the water sound becomes ‘chatty’ after it has undergone a more tumultuous transformation, yet there is no denying that it is water, because the transformation happen as we listen. From a political ecological perspective an audience member might describe the piece as trying to speak to us about the way we treat our waterways, however from an aesthetic perspective it sound as if the steam is singing as it merrily makes it way forward.

Evidence of Affordance: To what extent have the micro-structures of the source material permeated the final work?

The notion of moving water is quite evident within this piece. Also some of the transformations seem to mimic frog sounds. Although there were no frogs recorded, it adds to the sense that there is water about, and with it water species. There is also a low gurgling sound that sounds like water gurgling through pipes.

The structural forms used in this piece all had unique qualities, as mentioned previously, that supported analytical thinking about ways to compose this piece.

6. AREAS TO IMPROVE

The eco-structural approach was not strictly adhered to in this composition. Whilst all the sounds were made using this technique, the arrangement was not. A stronger commitment to the process would be required to discover the full potential of this compositional technique. Perhaps, like any ‘serial’ process, trust in it develops through experience, and perhaps blind adherence is not the path to satisfactory expressiveness.

One way to encourage a more strict approach would be to use a lot less data. One small piece of recorded sound has so many possibilities that in order to create a cohesive musical piece, it might be useful to limit the compositional explorations to just one sound source, in the same way that one tone-row in atonal serialism is used to give the piece a sense of internal coherency.

Another aspect of being more strict to the eco-structural approach would be to create a piece in which the source sound is used only as structural data and not used as audio material—even if transformed. Having the source sound playing, as in Flow, seems too easy a way of making the listener aware of what the sound source is.

7. CONCLUSION

We have described eco-structuralism and shown a detailed example of how it can be used in practice. Although eco-structuralism is a recent technique in composition, and although there are still many more avenues to explore, we feel this exploration indicates that there are many interesting possibilities. We have also suggested and demonstrated some techniques for analysis and critique of eco-structural music and we suggest that there is value in pursuing this technique further.

8. REFERENCES


