How the audio relates to the earthquake

The earthquake ground acceleration recording has been separated into 32 waves of different frequencies, like breaking a Lego building down to its bricks. The two main features of waves that are used to create the audio are their frequency (how many cycles they do per second) and their ground acceleration (how high the wave is at a point).

Higher frequency/faster waves are assigned to higher pitches (yellow on the graphs). Lower frequency/slower waves are assigned to lower pitches (indigo on the graphs). Because all the waves in an earthquake are pretty low frequency (between 0 and 100 Hz) the pitch assigned is scaled up from the actual frequency of the wave. Without this the audio would all be very bassy and harder to hear.

The acceleration shown by the waves decides how long and loud the notes are. Large accelerations are shown with long, loud notes. Smaller accelerations are shown with lots of small, quiet notes. This means large waves are more noticeable while smaller waves create more of a drone in the background.

Since the acceleration at each frequency changes with time at different points in the recording you might hear different pitches more clearly than others. Often there will be more small low frequency waves before and after the main part of the earthquake, so there will be a low pitched drone.

Interesting features of an earthquake

Features that depend on the soil type and location will be most apparent in real recordings of earthquakes as opposed to simulated recordings. Since there are multiple factors that influence how shaking is felt at a location there are no straightforward explanations that can be applied to all recordings. The descriptions below show how you could use the audio to demonstrate site effects, but it may not be clear from a recording which effect is having the most impact.

Magnitude versus intensity

Magnitude is how much energy is released by the earthquake while intensity is how strong it feels. This means that intensity varies a lot depending on location. Since the audio is made from a recording at a location the audio shows the intensity of the earthquake at that location. The audio does not necessarily show the magnitude of the earthquake.

Example

The 2016 Kaikōura earthquake was magnitude 7.8 and the 2010 Darfield earthquake was magnitude 7.1. However, in Castle Hill the simulated Darfield earthquake recording is noticeably louder than the simulated Kaikōura recording. This means the shaking in Castle Hill from the Darfield earthquake was more intense.

How distance affects the waves

As the waves travel through the ground the energy is becoming more spread out so the amplitudes of all waves decrease slightly. High frequency waves are also damped more than low frequencies when travelling through soil. This means earthquakes recorded closer to the epicentre have more high frequency waves present so the audio will have louder high-pitched notes. Recordings far from the epicentre will be quieter and lower pitched overall.

Example
The simulated 2016 Kaikōura earthquake is much louder and more high pitched when recorded in Kaikōura than when recorded in Christchurch.

Rock, soil, and sediment basins, oh my!
Earthquake waves travel more quickly through rock than they do through soil, so in general earthquakes on rock will feel like more of a jolt. In soil there is also more damping than in rock so high frequencies die away much faster in soil. This means that in general recordings on rock will be high pitched while recordings on soil will be low pitched.

Sediment basins have a lot of soil sitting in a basin of rock. Earthquake waves can be reflected back and forth between the soil-air and soil-rock interfaces, which means the shaking can be felt for longer. This is most noticeable in large sediment basins like the Canterbury basin. The basin can also amplify low frequency waves, while shallow soils might amplify high frequency waves.

Example
Historic recordings of the 2011 Christchurch earthquake show a large difference between the shaking at Heathcote Valley Primary School (HVSC sensor) and the Central City (REHS sensor at Christchurch Resthaven). HVSC is very loud and high pitched, with the peak happening quite suddenly in the first 10 seconds. In contrast REHS is a little quieter and much lower pitched, with the peak taking a bit longer to build up and die away. This is mostly due to differences in the site soil conditions. HVSC is on shallow soil that might have amplified high frequencies. REHS is on deep soil in the basin, which meant high frequencies were heavily damped and the shaking was slightly extended by the basin effect.

Why some buildings are affected more than others
All buildings have a resonant frequency that they naturally like to shake at. Tall buildings have a lower resonant frequency since they take longer to swing from one side to the other. Short buildings have a higher resonant frequency since they don't take as long to shake back and forth. When the main frequency of an earthquake is similar to the resonant frequency of a building it's like pushing someone on a swing at just the right time. This means an earthquake can damage certain buildings much more than others. If the audio at the location is high pitched that means there are more high frequencies so short buildings will be more affected. If the audio is low pitched that means there are more low frequencies so more tall buildings are likely to be damaged than short buildings.

How fault length affects the waves released
The length of the fault measures how long the earthquake's slip surface was. The longer the fault is the longer the wavelengths it creates can be. This means long faults can create waves with very low frequencies. Shorter faults can't reach those low frequencies, which means the audio is higher pitched. Long faults generally also produce earthquakes with larger magnitudes since there is more material sliding and so more energy released.

Shaking on hill tops (topographic amplification)

The earthquake waves can be reflected off the soil-air interface of the hill. This can result in high frequency waves being directed up towards the top of the hill. This causes more intense shaking at the peak, so the audio would have louder high pitches.