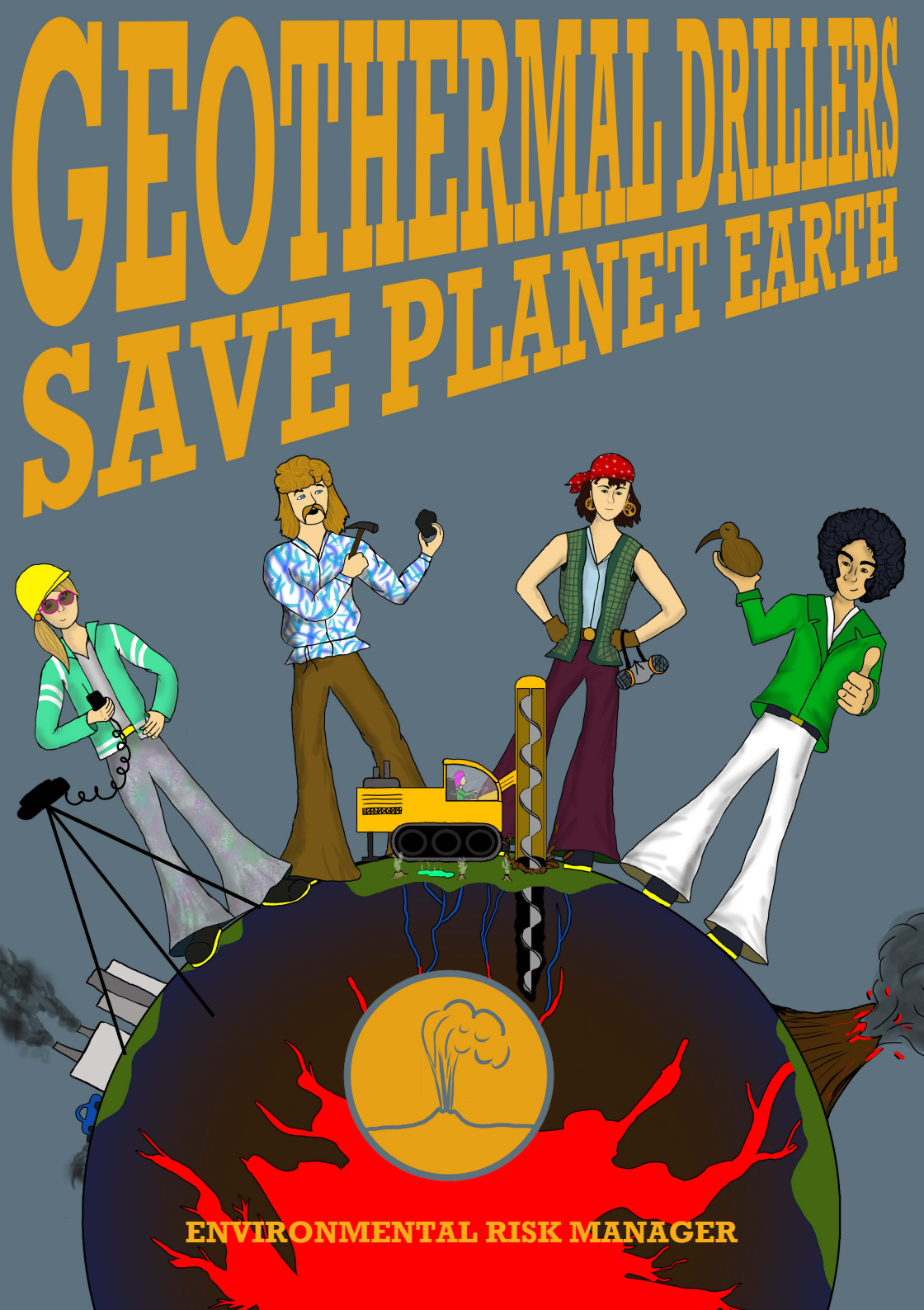
GEOTHERMAL DRILLERS SAVE PLANET EARTH



Drilling for Geothermal Energy!

WELCOME MAGMA DRILLERS!

Welcome to the magma drillers game! During this game you will learn to interpret scientific data to make a decision about where and how you should drill in magmatically active areas.

You will also learn what behaviour is expected of scientists, and you will be asked to sign a code of conduct.

SCIENTIST CODE OF CONDUCT

Based on the NASA Astronaut Code of Professional Responsibility

COMPETENCE | NGANA "MĀS TE HINGA, KA TUTUKI"

There is uncertainty involved with new scientific endeavours, so try your best to be prepared for your role. Failure is part of the design cycle on the pathway to success.

TEAMWORK | MANI TAHI "MAHIA TE MAHI KO HOROTAI TE WHIWHI"

Scientific endeavours are the result of collaboration and the end result reflects the strength of the team.

INTEGRITY | NGĀKAU PONO

As responsible scientists, it is important that you seek to support your ideas with evidence and look for evidence supporting others' explanations. Be open to critique of your ideas.

Drilling for Geothermal Energy!

RELATIONSHIPS | WHAKAWHANAUNGATANGA

Science is hard work, so be open to new learning, trust each other. Be aware of how your words and actions affect other people.

PERSONAL BEHAVIOUR | TINO RANGATIRATANGA

Accept personal responsibility for your behaviour. Be respectful and supportive of your team members and others during this mission.

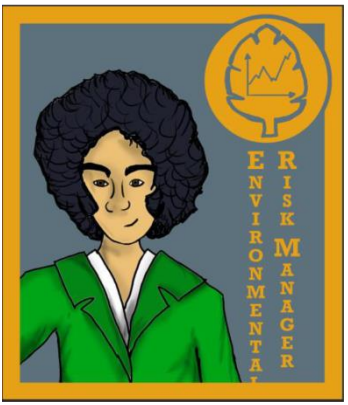
STEWARDSHIP | KAITIAKITANGA

Resources are precious –as a responsible citizen it is important that you use resources wisely and take steps to reduce your impact on local communities, and protect the important natural features of our planet.

Name: _____ **Signature**: _____

Date: _____

Your role: Environmental Risk Manager



The environmental risk manager is probably the most underrated job on the team. This role includes being aware of what could go wrong, in order to avoid damage to natural features and infrastructure, or even worse serious injury or loss of life. Without careful consideration of the risks associated with an activity, your team won't know what to do when something goes wrong. If you are not prepared for unexpected events, it is likely that your project will delayed or cancelled. This means that the risk manager makes final decisions on whether drilling should go ahead or not.

Risk of an activity is evaluated by determining the likelihood of something happening, and comparing it to the consequence of that event. In our case, it is possible to reduce the risk associated with drilling by either moving the site, or by engineering safety solutions. Reducing risk can be costly, so a risk

manager is required to be creative with his solutions, in order to make sure that everybody is safe, the environment is preserved, and everybody enjoys the benefits of the project!

Drilling for Geothermal Energy!

Mission 1: Renewable Energy

It is the year 1974, the Beatles have broken up, the world is running out of energy resources and excuses to party and, new innovative groups of people were developing amazing ideas like Rap music, Star wars and geothermal power.

You are part of a hand-picked team of heroes with puffy hair, moustaches and glitter where it doesn't belong, put together to try to save the world's energy problems through guardianship of our resources. In remote Northern Iceland, an area where water heated deep in the earth reaches the surface, Icelanders are trying to follow in the footsteps of the brave New Zealand and Italian pioneers to harness Earths natural heat to make energy.

In order to complete this mission, you will have to watch both the introduction video and the risk manager video.

In this mission, you will be asked to collaborate with other scientists in order to extract renewable energy

out of the ground. Your job, as a risk manager, will be to use the knowledge you have gained to ensure that the drilling activity is resilient and has the ability to react positively in case of a negative consequence to the drilling.

The information on the following pages will help you answer the questions below. Once you are confident about your answers to those questions, you will be able to report back to your team and help make a final decision on where and how to drill.

Hazard information

The hazards that could potentially affect the drilling operations are the following:

- Destroying valued natural features.
- Causing volcanic eruptions.

Your task is to assess the risk level of each events happening, and developing protocols (a set of rules) to follow.

Natural features

Natural geothermal features, such as fumaroles, are present at Krafla. These are a hazard because they can cause burns and injuries if you step or fall into them, however the main concern is that these features are beautiful and culturally significant, and therefore need to be protected. The likelihood of affecting a fumarole depends on how far the drilling site is from the fumarole itself –the closer you are the more likely you will damage the fumarole.

The consequence of damaging a fumarole would be catastrophic, as once these are damaged, you cannot undo the harm that has been done. However, contingency plans for a fumarole would involve

monitoring the fumaroles for changes as drilling occurs, and modifying your drill plan if the changes do occur.

Volcanic eruptions: Ashfall

The two main types of volcanic eruptions are explosive ash generating eruptions, and lava outpourings known as lava flows.

Ashfall can have drastic negative consequences on the drilling operations. Breathing in ash can cause respiratory problems, and ash can cause mechanical and electrical failure of equipment associated with drilling. As ash travels quite far, it is difficult to reduce the negative consequences of the ash by moving the site, so engineering or contingency solutions have to be explored.

Volcanic eruptions: Lava Flows

The risk associated with lava flows is quite real- lava flows have spewed out the Krafla volcano many times in the past. The consequences are low to life, as lava moves very slowly, but can be catastrophic to equipment that is immobile. With a bit of planning, you can design a site to divert lava flows

away from equipment. If the drill site has been designed appropriately, the consequence of a lava flow would be marginal.

Question 1 Lava flows

What measures do you need to protect yourself from lava flows?

With those measures in place, what is the consequence of a lava flow affecting your drill site?

Question 2 Natural features

Distance from fumarole	Likelihood of affecting fumarole
0-500	Likely
500m +	Rare

What is the likelihood of affecting a fumarole if you are closer than 500m to a fumarole?

Question 3: Risk assessment

Use the following risk planning tool to assess the risk with the different hazards.

		Consequence	
Likelihood		**Marginal**	**Catastrophic**
	Likely	High	Extreme
	Rare	Low	High

Hazard	Probability	Consequence	Risk Level
Ashfall	***Rare***	***Catastrophic***	***High***
Lava flows(with lava diversion)			
Fumarole (0-500m)			
Fumarole (above 500m)			

Question 4: Hazard Protocol

What action must you take if your drillhole site is located within 0-500m of a fumarole?

_____

_____

_____

What action must you take if your drillhole site is located more than 500m of a fumarole?

Question 5 Risk reduction

There are 3 key methods to reduce the risks from the hazards identified at Krafla Volcano. Identify which method is most effective at reducing the risk by matching the method to the hazard.

Location of the drilling site	Lava flows
Design safety features at the site	Ash eruptions
Contingency plans	Fumarole

Well done. Stop here and consult with your team before moving on!

Drilling Plan Evaluation

Take a moment to think about how your first mission went.What did your team do well when making your drilling plan?

What is one thing your team could do better when planning together for the next mission?

Did everyone feel that they contributed to the final plan?

1 2 3 4 5

CURIOUS MINDS
HE HIHIRI I TE MAHARA

UC
UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND