

Rockfall source area dimensions

<u>Slope Zone</u>	<u>Height (m)</u>	<u>Length (m)</u>	<u>Area (m2)</u>
1	20	25	500
2	20	200	4,000
3	20	100	2,000
4	50	50	2,500
5	10	50	500
6	10	50	500
TOTAL			10,000

Rockfall hazard category

% of rocks of various sizes reaching hazard category rating 1 to 5:

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
1m boulders	100%	90%	75%	30%	10%
300mm rocks	100%	50%	10%	0%	0%
150mm rocks	90%	20%	0%	0%	0%
Vulnerability	0.4	0.3	0.2	0.1	0.7

Mauao 'natural' rockfall frequency estimate

<u>Trigger:</u>	<u>Weathering</u>	<u>Seismic</u>	<u>Animal</u>	<u>TOTAL</u>
1m boulders	1	0.3	0	1.3
300mm rocks	10	3	0	13
150mm rocks	100	30	50	180

Rockfall allocated into in the various slope zones

<u>Zone</u>	<u>Natural 1m</u>	<u>Natural 300mm</u>	<u>Natural 150mm</u>	<u>Human 1m</u>	<u>Human 300mm</u>	<u>Human 150mm</u>
1	0.065	0.65	9	0	0	25
2	0.52	5.2	72	0	0	0
3	0.26	2.6	36	0	0	0
4	0.325	3.25	45	0	0	50
5	0.065	0.65	9	0	0	0
6	0.065	0.65	9	0	0	0
TOTAL	1.3	13	180	0	0	75
TOTAL						269.3

Total Rockfall Frequency

1m Freq/m ² source	0.0001
300mm Freq/m ² source	0.0013
150mm Freq/m ² source	0.0255

Visitor No's

Upper Tracks	75,000
Base Track	350,000

Rockfall risk calculation

<u>Zone</u>	<u>Track</u>	<u>Hazard Category</u>	<u>Track Length</u>	<u>Annual Rocks Crossing</u>	<u>Incremental Risk</u>	<u>Return Period</u>	<u>Fatality Frequency</u>
1	Waikorere	1	50	7.18	6.E-08	217	5.E-03
1&2	Base	4	600	0.18	6.E-10	4,667	2.E-04
2	Waikorere	2	400	17.47	1.E-07	89	1.E-02
2	Oruahine	3	450	0.91	5.E-09	2,567	4.E-04
3	Oruahine	3	250	0.46	3.E-09	5,134	2.E-04
3	Base	4	400	0.08	3.E-10	10,268	1.E-04
4	Oruahine	1	150	89.08	1.E-06	13	8.E-02
4	Base	3	250	0.57	4.E-09	695	1.E-03
5	Oruahine	1	200	8.82	1.E-07	133	8.E-03
5	Base	3	200	0.11	8.E-10	3,521	3.E-04
6	Base	4	500	0.02	7.E-11	42,784	2.E-05
1&6	Campground t (1 week stay)	5	400	0.01	2.E-07	879	1.E-03
TOTAL						10	1.E-01

Mauao Rockfall Risk Calculation

ZONE 1 WAIKORERE TRACK (cat 2)

Source area of bluffs & over-steep colluvium (m ²)	m ²	500
1m 'natural' rockfall from source area		0.07
300mm 'natural' rockfall from source area		0.65
150mm 'natural' rockfall from source area		9.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		25.00
Total rockfall triggered above		34.72
% 1m boulders reaching	%	90%
% 300mm boulders reaching	%	50%
% 150mm boulders reaching	%	20%
No of 1m boulders reaching		0.06
No of 300mm boulders reaching		0.33
No of 150mm boulders reaching		6.80
Total annual rockfall reaching		7.18
Length of affected track section (m)	m	50
Rockfall intensity (annual rocks per metre)		1.44E-01
Total time walking affected track section (minutes)	min	2
Stopping time	min	0
Total time on affected track section (years)	years	2.85E-06
Ratio person length (0.5m) to affected track section		1.00E-02
Probability of rock coinciding with one person traverse		2.05E-07
Vulnerability (to fatality)		0.3
Probability of fatality per person traverse		6.15E-08
Number of visitors to track section per year		75,000
Probability of a fatality per year		4.61E-03
Return period of a fatality		217
Risk if static for one hour		8.20E-06

Mauao Rockfall Risk Calculation

ZONE 1 & 2 BASE TRACK (cat 4)

Source area of bluffs & over-steep colluvium (m ²)	m ²	4,500
1m 'natural' rockfall from source area		0.59
300mm 'natural' rockfall from source area		5.85
150mm 'natural' rockfall from source area		81.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		25.00
Total rockfall triggered above		112.44
% 1m boulders reaching	%	30%
% 300mm boulders reaching	%	0%
% 150mm boulders reaching	%	0%
No of 1m boulders reaching		0.18
No of 300mm boulders reaching		0.00
No of 150mm boulders reaching		0.00
Total annual rockfall reaching		0.18
Length of affected track section (m)	m	600
Rockfall intensity (annual rocks per metre)		2.93E-04
Total time walking affected track section (minutes)	min	18
Stopping time	min	4
Total time on affected track section (years)	years	4.19E-05
Ratio person length (0.5m) to affected track section		8.33E-04
Probability of rock coinciding with one person traverse		6.12E-09
Vulnerability (to fatality)		0.1
Probability of fatality per person traverse		6.12E-10
Number of visitors to track section per year		350,000
Probability of a fatality per year		2.14E-04
Return period of a fatality		4667
Risk if static for one hour		1.67E-08

Mauao Rockfall Risk Calculation

ZONE 2 WAIKORERE TRACK (cat 2)

Source area of bluffs & over-steep colluvium (m ²)	m ²	4,000
1m 'natural' rockfall from source area		0.52
300mm 'natural' rockfall from source area		5.20
150mm 'natural' rockfall from source area		72.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		0.00
Total rockfall triggered above		77.72
% 1m boulders reaching	%	90%
% 300mm boulders reaching	%	50%
% 150mm boulders reaching	%	20%
No of 1m boulders reaching		0.47
No of 300mm boulders reaching		2.60
No of 150mm boulders reaching		14.40
Total annual rockfall reaching		17.47
Length of affected track section (m)	m	400
Rockfall intensity (annual rocks per metre)		4.37E-02
Total time walking affected track section (minutes)	min	12
Stopping time	min	0
Total time on affected track section (years)	years	2.28E-05
Ratio person length (0.5m) to affected track section		1.25E-03
Probability of rock coinciding with one person traverse		4.99E-07
Vulnerability (to fatality)		0.3
Probability of fatality per person traverse		1.50E-07
Number of visitors to track section per year		75,000
Probability of a fatality per year		1.12E-02
Return period of a fatality		89
Risk if static for one hour		2.49E-06

Mauao Rockfall Risk Calculation

ZONE 2 ORUAHINE TRACK (cat 3)

Source area of bluffs & over-steep colluvium (m ²)	m ²	4,000
1m 'natural' rockfall from source area		0.52
300mm 'natural' rockfall from source area		5.20
150mm 'natural' rockfall from source area		72.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		0.00
Total rockfall triggered above		77.72
% 1m boulders reaching	%	75%
% 300mm boulders reaching	%	10%
% 150mm boulders reaching	%	0%
No of 1m boulders reaching		0.39
No of 300mm boulders reaching		0.52
No of 150mm boulders reaching		0.00
Total annual rockfall reaching		0.91
Length of affected track section (m)	m	450
Rockfall intensity (annual rocks per metre)		2.02E-03
Total time walking affected track section (minutes)	min	14
Stopping time	min	0
Total time on affected track section (years)	years	2.57E-05
Ratio person length (0.5m) to affected track section		1.11E-03
Probability of rock coinciding with one person traverse		2.60E-08
Vulnerability (to fatality)		0.2
Probability of fatality per person traverse		5.19E-09
Number of visitors to track section per year		75,000
Probability of a fatality per year		3.90E-04
Return period of a fatality		2567
Risk if static for one hour		1.15E-07

Mauao Rockfall Risk Calculation

ZONE 3 ORUAHINE TRACK (cat 3)

Source area of bluffs & over-steep colluvium (m ²)	m ²	2,000
1m 'natural' rockfall from source area		0.26
300mm 'natural' rockfall from source area		2.60
150mm 'natural' rockfall from source area		36.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		0.00
Total rockfall triggered above		38.86
% 1m boulders reaching	%	75%
% 300mm boulders reaching	%	10%
% 150mm boulders reaching	%	0%
No of 1m boulders reaching		0.20
No of 300mm boulders reaching		0.26
No of 150mm boulders reaching		0.00
Total annual rockfall reaching		0.46
Length of affected track section (m)	m	250
Rockfall intensity (annual rocks per metre)		1.82E-03
Total time walking affected track section (minutes)	min	8
Stopping time	min	0
Total time on affected track section (years)	years	1.43E-05
Ratio person length (0.5m) to affected track section		2.00E-03
Probability of rock coinciding with one person traverse		1.30E-08
Vulnerability (to fatality)		0.2
Probability of fatality per person traverse		2.60E-09
Number of visitors to track section per year		75,000
Probability of a fatality per year		1.95E-04
Return period of a fatality		5134
Risk if static for one hour		1.04E-07

Mauao Rockfall Risk Calculation

ZONE 3 BASE TRACK (cat 4)

Source area of bluffs & over-steep colluvium (m ²)	m ²	2,000
1m 'natural' rockfall from source area		0.26
300mm 'natural' rockfall from source area		2.60
150mm 'natural' rockfall from source area		36.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		0.00
Total rockfall triggered above		38.86
% 1m boulders reaching	%	30%
% 300mm boulders reaching	%	0%
% 150mm boulders reaching	%	0%
No of 1m boulders reaching		0.08
No of 300mm boulders reaching		0.00
No of 150mm boulders reaching		0.00
Total annual rockfall reaching		0.08
Length of affected track section (m)	m	400
Rockfall intensity (annual rocks per metre)		1.95E-04
Total time walking affected track section (minutes)	min	12
Stopping time	min	3
Total time on affected track section (years)	years	2.85E-05
Ratio person length (0.5m) to affected track section		1.25E-03
Probability of rock coinciding with one person traverse		2.78E-09
Vulnerability (to fatality)		0.1
Probability of fatality per person traverse		2.78E-10
Number of visitors to track section per year		350,000
Probability of a fatality per year		9.74E-05
Return period of a fatality		10268
Risk if static for one hour		1.11E-08

Mauao Rockfall Risk Calculation

ZONE 4 ORUAHINE TRACK (cat 1)

Source area of bluffs & over-steep colluvium (m ²)	m ²	2,500
1m 'natural' rockfall from source area		0.33
300mm 'natural' rockfall from source area		3.25
150mm 'natural' rockfall from source area		45.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		50.00
Total rockfall triggered above		98.58
% 1m boulders reaching	%	100%
% 300mm boulders reaching	%	100%
% 150mm boulders reaching	%	90%
No of 1m boulders reaching		0.33
No of 300mm boulders reaching		3.25
No of 150mm boulders reaching		85.50
Total annual rockfall reaching		89.08
Length of affected track section (m)	m	150
Rockfall intensity (annual rocks per metre)		5.94E-01
Total time walking affected track section (minutes)	min	5
Stopping time	min	0
Total time on affected track section (years)	years	8.56E-06
Ratio person length (0.5m) to affected track section		3.33E-03
Probability of rock coinciding with one person traverse		2.54E-06
Vulnerability (to fatality)		0.4
Probability of fatality per person traverse		1.02E-06
Number of visitors to track section per year		75,000
Probability of a fatality per year		7.63E-02
Return period of a fatality		13
Risk if static for one hour		3.39E-05

Mauao Rockfall Risk Calculation

ZONE 4 BASE TRACK (cat 3)

Source area of bluffs & over-steep colluvium (m ²)	m ²	2,500
1m 'natural' rockfall from source area		0.33
300mm 'natural' rockfall from source area		3.25
150mm 'natural' rockfall from source area		45.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		50.00
Total rockfall triggered above		98.58
% 1m boulders reaching	%	75%
% 300mm boulders reaching	%	10%
% 150mm boulders reaching	%	0%
No of 1m boulders reaching		0.24
No of 300mm boulders reaching		0.33
No of 150mm boulders reaching		0.00
Total annual rockfall reaching		0.57
Length of affected track section (m)	m	250
Rockfall intensity (annual rocks per metre)		2.28E-03
Total time walking affected track section (minutes)	min	8
Stopping time	min	2
Total time on affected track section (years)	years	1.81E-05
Ratio person length (0.5m) to affected track section		2.00E-03
Probability of rock coinciding with one person traverse		2.06E-08
Vulnerability (to fatality)		0.2
Probability of fatality per person traverse		4.11E-09
Number of visitors to track section per year		350,000
Probability of a fatality per year		1.44E-03
Return period of a fatality		695
Risk if static for one hour		1.30E-07

Mauao Rockfall Risk Calculation

ZONE 5 ORUAHINE TRACK (cat 1)

Source area of bluffs & over-steep colluvium (m ²)	m ²	500
1m 'natural' rockfall from source area		0.07
300mm 'natural' rockfall from source area		0.65
150mm 'natural' rockfall from source area		9.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		0.00
Total rockfall triggered above		9.72
% 1m boulders reaching	%	100%
% 300mm boulders reaching	%	100%
% 150mm boulders reaching	%	90%
No of 1m boulders reaching		0.07
No of 300mm boulders reaching		0.65
No of 150mm boulders reaching		8.10
Total annual rockfall reaching		8.82
Length of affected track section (m)	m	200
Rockfall intensity (annual rocks per metre)		4.41E-02
Total time walking affected track section (minutes)	min	6
Stopping time	min	0
Total time on affected track section (years)	years	1.14E-05
Ratio person length (0.5m) to affected track section		2.50E-03
Probability of rock coinciding with one person traverse		2.52E-07
Vulnerability (to fatality)		0.4
Probability of fatality per person traverse		1.01E-07
Number of visitors to track section per year		75,000
Probability of a fatality per year		7.55E-03
Return period of a fatality		133
Risk if static for one hour		2.52E-06

Mauao Rockfall Risk Calculation

ZONE 5 BASE TRACK (cat 3)

Source area of bluffs & over-steep colluvium (m ²)	m ²	500
1m 'natural' rockfall from source area		0.07
300mm 'natural' rockfall from source area		0.65
150mm 'natural' rockfall from source area		9.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		0.00
Total rockfall triggered above		9.72
% 1m boulders reaching	%	75%
% 300mm boulders reaching	%	10%
% 150mm boulders reaching	%	0%
No of 1m boulders reaching		0.05
No of 300mm boulders reaching		0.07
No of 150mm boulders reaching		0.00
Total annual rockfall reaching		0.11
Length of affected track section (m)	m	200
Rockfall intensity (annual rocks per metre)		5.69E-04
Total time walking affected track section (minutes)	min	6
Stopping time	min	2
Total time on affected track section (years)	years	1.43E-05
Ratio person length (0.5m) to affected track section		2.50E-03
Probability of rock coinciding with one person traverse		4.06E-09
Vulnerability (to fatality)		0.2
Probability of fatality per person traverse		8.12E-10
Number of visitors to track section per year		350,000
Probability of a fatality per year		2.84E-04
Return period of a fatality		3521
Risk if static for one hour		3.25E-08

Mauao Rockfall Risk Calculation

ZONE 6 BASE TRACK (cat 4)

Source area of bluffs & over-steep colluvium (m ²)	m ²	500
1m 'natural' rockfall from source area		0.07
300mm 'natural' rockfall from source area		0.65
150mm 'natural' rockfall from source area		9.00
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		0.00
Total rockfall triggered above		9.72
% 1m boulders reaching	%	30%
% 300mm boulders reaching	%	0%
% 150mm boulders reaching	%	0%
No of 1m boulders reaching		0.02
No of 300mm boulders reaching		0.00
No of 150mm boulders reaching		0.00
Total annual rockfall reaching		0.02
Length of affected track section (m)	m	500
Rockfall intensity (annual rocks per metre)		3.90E-05
Total time walking affected track section (minutes)	min	15
Stopping time	min	3
Total time on affected track section (years)	years	3.42E-05
Ratio person length (0.5m) to affected track section		1.00E-03
Probability of rock coinciding with one person traverse		6.68E-10
Vulnerability (to fatality)		0.1
Probability of fatality per person traverse		6.68E-11
Number of visitors to track section per year		350,000
Probability of a fatality per year		2.34E-05
Return period of a fatality		42784
Risk if static for one hour		2.23E-09

Mauao Rockfall Risk Calculation

ZONE 1&2 CAMPGROUND BOUNDARY SITES (cat 5)

Source area of bluffs & over-steep colluvium (m ²)	m ²	1,000
1m 'natural' rockfall from source area		0.13
300mm 'natural' rockfall from source area		1.30
150mm 'natural' rockfall from source area		18.00
Total 'natural' rockfall from source area		19.43
1m 'human' rockfall from source area		0.00
300mm 'human' rockfall from source area		0.00
150mm 'human' rockfall from source area		25
Total rockfall triggered above		19.43
% 1m boulders reaching	%	10%
% 300mm boulders reaching	%	0%
% 150mm boulders reaching	%	0%
No of 1m boulders reaching		0.01
No of 300mm boulders reaching		0.00
No of 150mm boulders reaching		0.00
Total annual rockfall reaching		0.01
Length of affected section (m)	m	400
Rockfall intensity (annual rocks per metre)		3.25E-05
Stopping time = 1 day camp	min	720
Total time in affected section (years)	years	1.37E-03
Ratio person length (1m) to affected section		2.50E-03
Probability of rock coinciding with person		4.45E-08
Vulnerability (to fatality)		0.7
Probability of fatality per 1day stay		3.12E-08
Probability of fatality per 7day stay		2.18E-07
Persons at risk/day=50 sites x 50% occ x 4 persons		100
Probability of a fatality per year		1.14E-03
Return period of a fatality		879
Risk if static for one hour		3.71E-09