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# The Trail AI Intelligence Project: Te Araroa

## Predictive Trail Condition & Maintenance Analytics

### Final Report

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Date: June 15, 2026

**Disclaimer:** *This document is a mockup created for illustrative purposes only. The data, findings, and recommendations presented are based on a synthesized dataset and do not represent the results of completed research. Its purpose is to demonstrate the format and analytical depth of the final project deliverable.*

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## Executive Summary

This report details the findings of the Trail AI Intelligence Project, a 7-month initiative to develop a predictive maintenance model for New Zealand's Te Araroa trail<sup>4</sup>. The project successfully collected over 5,000 geotagged data points on trail conditions during a 5-month thru-hike<sup>5</sup>. This unique dataset was then enriched with topographical and environmental data to train a machine learning model capable of identifying future maintenance hotspots<sup>66</sup>.

A key finding from the model is that **70% of severe erosion events occur on south-facing slopes with an incline greater than 15 degrees**, particularly after significant rainfall<sup>7</sup>. This insight allows for a shift from a reactive to a proactive maintenance strategy.

The primary recommendation is for trail management organizations to implement a targeted assessment schedule for these high-risk sections following any official weather warnings<sup>8</sup>. The final project deliverable is an interactive "Risk Model" map, which provides a powerful visual tool for prioritizing resource allocation and building a more resilient trail network<sup>9</sup>.

## 1.0 Project Objectives

The project was designed to achieve three primary objectives:

1. **Collect** a comprehensive, standardized, ground-truth dataset of trail conditions and infrastructure integrity along the entire 3,000km Te Araroa corridor<sup>10</sup>.
2. **Develop** a machine learning model to analyze this data, identify key predictors of trail degradation, and forecast future maintenance requirements<sup>11</sup>.
3. **Deliver** a set of actionable tools and strategic recommendations to trail management partners, enabling data-driven decision-making for maintenance and resource allocation<sup>12</sup>.

## 2.0 Methodology

### 2.1 Field Data Collection Protocol

Data was collected using a mobile GIS application configured with a specific data schema 13. The protocol included both "Event-Driven Logging" for observed issues and scheduled "Nominal Check-ins" to create a baseline of standard trail conditions, preventing model bias<sup>14</sup>.

### 2.2 Data Enrichment & Feature Engineering

In the post-hike phase, the raw dataset of GPS points was programmatically enriched with external data sources<sup>15</sup>. This included querying a Digital Elevation Model (DEM) of New Zealand to derive the **slope, elevation, and aspect** for each point<sup>16</sup>. Weather APIs were used to append historical data, such as **total rainfall in the past 7 days** and freeze-thaw cycles<sup>17</sup>.

### 2.3 Predictive Model Architecture

The enriched dataset was used to train a Gradient Boosted Machine (XGBoost) to solve a classification problem: predicting the `Severity_Score` of a given trail segment based on its topographical and environmental features<sup>18</sup>.

## 3.0 Key Findings & Analysis

### Finding 3.2: South-facing slopes are disproportionately at risk for severe erosion.

The model's feature importance analysis reveals that **slope** and **aspect** are the two biggest predictors of severe erosion events (Severity Score 4-5)<sup>19</sup>. Our analysis of the 1,200km South Island dataset shows that over

**70% of severe erosion occurs on south-facing slopes with an incline greater than 15 degrees**<sup>20</sup>. These areas are less exposed to drying sunlight and are therefore more susceptible to soil saturation, especially following multi-day rain events<sup>21</sup>.

### Chart: Erosion Events by Slope & Aspect

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## 4.0 Predictive Risk Model: Visual Analysis

The primary analytical tool delivered by this project is the interactive "Risk Model" map. This tool provides a geographic visualization of both the collected data and the model's predictions.

Users can click on any of the thousands of data points to view its associated information, including the issue category, severity score, descriptive notes, and field photos<sup>22</sup>. The map also features a "Risk Overlay," where the trail line itself is color-coded from green to red, indicating the model's predicted risk of degradation for that section under various conditions<sup>23</sup>. This allows managers to visually identify and explore potential hotspots before they become critical failures.

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## 5.0 Strategic Recommendations

Based on the model's findings, we offer the following strategic recommendations:

1. **Implement Targeted Assessments:** Proactively schedule assessments of all south-facing trail sections with a slope  $>15^\circ$  immediately following any MetService rainfall warning.
2. **Standardize Infrastructure Review:** Implement a standardized review of all wooden bridges and stiles in sections that experience more than 10 freeze-thaw cycles per season, as the model indicates this is a high predictor of 'Infrastructure Damage' reports.
3. **Update Volunteer Briefings:** Use the "Risk Model" map to brief volunteer crews on which trail sections are most likely to have sustained damage after weather events, allowing for more efficient deployment.

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