GROUND TRUTH
ENGINEERING ROADS THROUGH THE FOREST

Forestry roads must carry some of New Zealand's heaviest vehicles through steep and variable terrain without allowing water, sediment or unstable ground to undermine the road or damage the environment. Mark Brown of Tahurua Earthmovers explains how forestry roads are planned, ground-truthed, constructed and protected throughout their working life.

Meet Mark Brown

Mark Brown, Operations Manager at Tahurua Earthmovers, works where plans on a screen meet the physical reality of the land.

Before harvesting begins, crews need safe roads capable of carrying heavy machinery and loaded logging trucks through challenging terrain. These roads must also control runoff, minimise erosion and protect waterways.

Mark brings more than 40 years of forestry experience to this work, having worked across almost every aspect of the industry. His knowledge shows how forestry roading combines engineering, environmental understanding and practical harvesting experience. As Mark explains, construction begins with a harvest plan, but the final decisions must be tested on the ground.



WHAT DOES A FORESTRY ROADING CONTRACTOR DO?

The forest owner or manager provides a harvest plan showing where the trees will be harvested and where roads and landings are expected to go. A landing, sometimes called a skid site, is the working area where trees or logs are brought, processed, sorted and loaded onto trucks. Mark's team helps turn that plan into physical infrastructure. The work can include:

- clearing the road corridor of trees and vegetation;
- stripping unsuitable organic material and topsoil;
- excavating and moving soil and rock;
- forming cut and fill slopes;
- compacting the road foundation;
- applying aggregate, commonly called metal;
- constructing landings and truck-access areas;
- installing culverts, drains, berms and flumes; and
- stabilising exposed ground and maintaining environmental controls.

The underlying engineering principles are similar to those used in civil road construction, but forestry roads have a distinctive purpose and life cycle. A road may experience its most intensive use during a relatively short harvesting period, when it must withstand repeated passes by heavy machinery and logging trucks. After harvesting, it may remain in the forest for another 25 years or more before the next rotation is ready.

The road must therefore be fit for purpose: strong and safe for the traffic it will carry, environmentally responsible, economical to construct and capable of being maintained over its required life.

FROM A DIGITAL PLAN TO THE REAL LANDSCAPE

DISCOVER FORESTRY

Modern harvest planning uses contour maps, aerial photographs, LiDAR and GIS data to identify slopes, waterways, boundaries and harvest areas. However, digital information cannot reveal every spring, soft patch, rock outcrop or unstable slope.

That is why Mark emphasises ground-truthing:
"You begin with a plan developed using maps and computer-based information. You then take that plan into the field and verify whether it accurately represents what is actually there on the ground."

By walking the proposed roadline, planners can identify difficult gradients, unstable or erosion-prone ground, waterways, drainage outlets and areas that must be protected. They also check that there is enough space for corners, passing bays and landings. If the route is unsafe, impractical or environmentally risky, it is modified.

Even a small change can affect the road's gradient, earthworks, drainage requirements and cost. Ground-truthing is therefore an essential form of engineering risk management.



SEVEN KILOMETRES AND MILLIONS OF DOLLARS OF INFRASTRUCTURE

Since January, Tahurua Earthmovers has constructed approximately seven kilometres of forestry road at the site Mark discusses.

He estimates that forestry-road construction commonly costs between $180 and $300 per lineal metre, depending on the terrain and ground conditions.

That is approximately $180,000 to $300,000 per kilometre. At those indicative rates, seven kilometres represents around $1.26 million to $2.1 million of road construction.

These figures show why route selection matters. A longer road, a difficult rock cutting, unstable ground, extensive drainage work or the need to cart excavated material to a disposal site can increase the cost substantially.

The cheapest-looking line on a map is not necessarily the safest or most economical route once the site is inspected.

When the Roadline meets Hard Rock

DISCOVER FORESTRY NEW ZEALAND



In this clip, Mark shows a section where the road construction team has encountered hard rock within the hillside. The exposed rock face reveals why ground-truthing and geological knowledge matter: material that appears as a contour on a plan behaves very differently when an excavator begins forming the road.

Soil can usually be excavated with a bucket, shaped and if it is suitable compacted into fill. Competent rock may be much slower and more difficult to remove. Depending on its hardness, jointing and the volume involved, contractors may need to use:

- a heavy excavator fitted with a rock bucket;
- a ripper tooth to open fractured or weathered rock;
- a hydraulic breaker to split harder material;
- drilling and controlled blasting by appropriately qualified specialists; or
- a change to the road alignment or level to reduce the amount of rock excavation.

The choice is an engineering and economic decision. A large machine may have greater breakout force and production capacity, but access, working room, fuel use and the stability of the platform must also be considered.

The New Zealand Forest Road Engineering Manual emphasises that machinery must be matched to the terrain, geology and task and that the skill of the operator is as important as the machine itself.

Reading the rock

Hard rock does not automatically mean stable rock. Engineers and experienced operators examine:

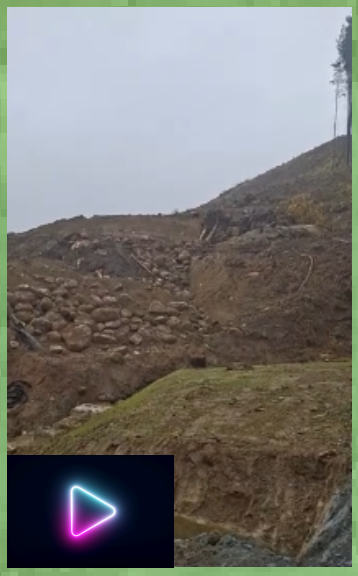
- the direction and spacing of joints or fractures;
- whether layers dip towards or away from the road;
- the degree of weathering;
- loose blocks that could fall onto the carriageway;
- groundwater emerging through cracks; and
- whether excavation has removed support from the slope above.

A rock cut may stand more steeply than a soil batter, reducing the total amount of excavation. However, an unsuitable batter angle or unfavourable bedding planes can create a rockfall or larger slope-failure hazard. Loose material must be removed or secured, drainage kept clear and the face monitored particularly after heavy rain.

Hard rock also affects time and cost. Production slows when each cubic metre takes longer to excavate. Attachments may need to be changed, equipment wear increases, and the road programme may need to be adjusted. This illustrates why the estimated cost of $180 $300 per lineal metre is a range rather than a fixed price.

Turning excavated rock into an engineering resource

DISCOVER FORESTRY NEW ZEALAND



Creating Safe Areas

In this clip, Mark explains how suitable rock recovered during excavation can be used elsewhere in the roadworks. Instead of treating every excavated boulder as waste, the team can sort material by size and engineering function.

This is an example of efficient cut-and-fill management. Material removed from one part of the road can sometimes help construct or protect another part, reducing the volume that must be trucked to a disposal area and the quantity of imported aggregate required.

The size and quality of the rock determine how it can be used.

- Large boulders can help form retaining or buttressing structures where these have been appropriately designed.
- Cobbles and large angular rock can be used as riprap to armour drains, flume outlets and other places exposed to fast-moving water.
- Smaller, durable crushed rock may be suitable for road pavement layers if it meets the required grading, strength and durability specifications.
- Unsuitable or weathered material must be placed in a stable disposal area rather than assumed to be structural fill.

The large rocks visible beside the flume provide physical protection to the earthworks. Where water is concentrated, appropriately sized rock helps absorb and spread its energy. It can reduce scour at the toe of a slope or around a drainage outlet and protect finer soil from being washed away.

Rock size and placement matter

Placing some rocks beside a drain is not automatically an engineered solution. The rock must be large enough and durable enough to resist the expected flow. Angular rock generally interlocks more effectively than rounded rock. It needs to be placed to avoid creating gaps through which finer soil can be washed, while the outlet must remain open and able to pass its design flow.

Large rocks are also unsuitable as an untreated running surface. Individual boulders or cobbles can move under repeated wheel loads, create an uneven surface and leave voids that admit water. When rock is intended for the pavement, it normally needs to be processed into a controlled range of particle sizes so that the pieces interlock and compact into a strong layer.

Reusing suitable site-won rock reduces truck movements, fuel use, construction costs and disturbance at quarries or disposal sites. It also provides readily available material for erosion protection. When carefully selected and correctly placed, rock excavated during road construction becomes part of the engineering solution.

Favourable and adverse gradients

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In the video, Mark identifies a relatively steep section with a gradient of approximately 12 to 12.5 % (percent).

A 12.5% gradient means the road rises or falls 12.5 metres for every 100 metres measured horizontally.

This is equivalent to an angle of approximately 7.1 degrees.

Mark describes this section as having a favourable grade because loaded logging trucks travel downhill and return uphill when empty.

In New Zealand forestry-road terminology:

- a favourable grade is downhill in the direction travelled by a loaded truck; and
- an adverse grade is uphill in the direction travelled by a loaded truck.

This distinction matters because a loaded logging truck demands much more from the road than an empty one.

On an adverse grade, the truck needs sufficient engine power and tyre traction to climb. Wheelspin can loosen aggregate, create corrugations and damage the pavement. Wet weather, loose surface material and potholes make it harder for the truck to maintain traction.

The direction in which logs will be transported is therefore considered while the road is being planned not after it has been built.

On a favourable grade, the loaded truck does not have to pull its load uphill, but the road is not automatically risk-free.

The driver must control a much heavier vehicle travelling downhill, so the alignment, surface, visibility, curve geometry and safe stopping distance remain important. The vehicle speed, braking and stability must all be considered.

The New Zealand Forest Road Engineering Manual identifies 12.5% as the maximum adverse grade for roads used by high-productivity motor vehicle logging trucks.

The manual also explains that steep adverse sections may require particularly well-constructed and compacted pavement, higher-quality surface aggregate or operational controls during wet conditions.

Engineering Connection
Pavement Strength

Forest roads generally use flexible aggregate pavements.
The pavement distributes concentrated axle loads through its layers and into the underlying subgrade. Its performance depends on factors such as:

- the strength and moisture content of the natural subgrade;
- the quality, size and grading of the aggregate;
- the depth of the pavement;
- the degree of compaction;
- drainage beneath and beside the road; and
- the number and weight of expected vehicle movements.

Water and loading interact. A saturated subgrade loses strength, while repeated heavy axle loads can deform a weak or poorly drained road.
Effective drainage is therefore part of structural road engineering, not merely an environmental addition.

Water: The Road Engineer's Constant Challenge

A forestry road changes the way water moves across a hillside. Rain falling on undisturbed forest soil may be intercepted by vegetation, infiltrate the ground or travel slowly through surface cover.

A compacted road is less permeable and can collect runoff from both the road surface and the cut slope above it.

If this water is allowed to build up, it can:

- soften and weaken the road pavement;
- create potholes, rutting and corrugations;
- scour drains and exposed slopes;
- saturate fill and contribute to slumping or failure;
- carry sediment downhill; and
- enter streams and affect freshwater habitats.

The aim is to control water from the moment it reaches the road until it is safely released.

Mark explained that culvert spacing is related to road gradient. The maximum interval may be about 100 metres in suitable conditions, but culverts are placed closer together as the road becomes steeper. Shorter spacing prevents excessive volumes of runoff from accumulating and reduces the speed and erosive power of the water reaching any single outlet.

Spacing is not determined by gradient alone. Engineers also consider catchment area, rainfall intensity, soil erodibility, natural drainage pathways and the consequences if a structure becomes blocked or fails.

managing water safely



Water management is one of the most important considerations when designing and maintaining roads in steep plantation forests.
If runoff or stream flow is not carefully controlled, moving water can erode road surfaces and slopes, wash sediment into waterways, destabilise earthworks and, in severe cases, contribute to slips or road failure.

In the clip above, Mark explains how several controls work together to manage water safely:

Concrete culvert: Provides a durable passage for water beneath the forest road. It must be large enough for heavy rainfall, with protected inlets and outlets to prevent erosion and undermining.

Debris dam: Positioned upstream, it intercepts branches and slash before they block the culvert. Regular inspection and debris removal are essential, particularly before and after heavy rain.

Poplar trees and vegetation: Their roots help stabilise erosion-prone soil, while vegetation slows runoff and filters sediment. Planting supports—but does not replace—well-designed drainage.

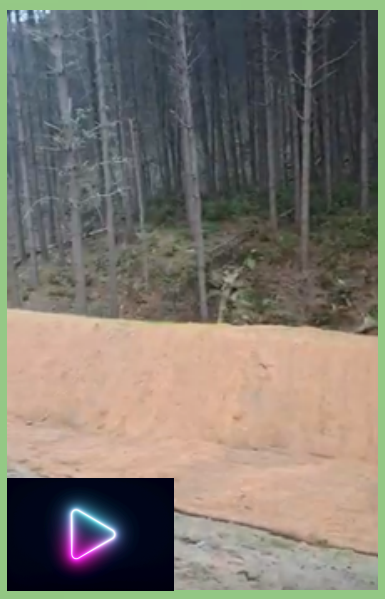
Together, these measures direct water safely, prevent blockages, reduce erosion and protect forest roads, downstream communities and freshwater ecosystems.

Flumes: carrying water across vulnerable ground



Mark also shows black flumes carrying runoff across loose or erodible fill to stable discharge points. Flumes must have a consistent fall, secure inlets and outlets, firm anchoring and protection against blockages, bypass and undermining. If they separate, twist or block, concentrated water can damage the slope they were designed to protect. Correct installation and regular inspection are therefore essential.

Extra protection near sensitive water



In this clip, Mark shows the additional protection used where exposed earthworks are close to a sensitive receiving environment. The erosion-control blanket visible on the ground shields the bare soil while the surface stabilises and vegetation becomes established.

The closer an exposed slope is to a stream, the smaller the margin for failure. Sediment produced at the road may have little opportunity to settle out before reaching the water. Engineers therefore use stronger or multiple controls where the environmental consequence is higher.

Coconut Matting works by:

- reducing the impact of raindrops on bare soil
- holding loose surface particles in place;
- slowing shallow water moving across the slope;
- retaining moisture that supports plant growth; and
- protecting seed and young vegetation while roots develop.

Coconut Matting must remain in close contact with the soil,
be correctly overlapped and be securely fixed at its top, sides and joins.

If water gets underneath the blanket, it can create hidden erosion channels.

A treatment train, not a single solution

Best practice relies on several controls working together. This can be understood as a treatment train:

1. Shape and compact the road so water does not pond on the carriageway.
2. Collect runoff in controlled drains or water tables.
3. Break up long flows with appropriately spaced culverts or cut-outs.
4. Use berms to keep water away from vulnerable fills.
5. Carry concentrated flow over erodible ground using flumes.
6. Slow and spread water at the outlet using rock, slash or vegetation.
7. Trap sediment before it can reach a waterway.
8. Stabilise bare soil using seed, mulch, matting or other suitable cover.

Each element performs a different function. Together they reduce the amount of soil detached, limit the water available to transport it and interrupt the pathway between the earthworks and the stream.

WORKING NEAR WATERWAYS

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Sediment is a natural part of river systems, but excessive sediment from disturbed land can increase turbidity, cover streambed habitat, affect aquatic insects and fish, and smother spawning areas.

Protection begins with road location. Before construction, Mark considers the distance from the proposed road to the waterway, the steepness and stability of the intervening slope, soil type, natural drainage paths and the likely consequence of a failure.

Where loose material could move into a perennial waterway, simply pushing excavated material over the side may be unacceptable. On steep or sensitive sites, material may need to be end-hauled: excavated, loaded into trucks and taken to a stable disposal area. This costs more, but it allows the road to be constructed on solid in-situ ground and reduces the risk of unstable fill entering a stream.

New Zealand's National Environmental Standards for Commercial Forestry set requirements for commercial forestry activities, including earthworks, river crossings, setbacks, stormwater and sediment management. Site-specific management plans identify the risks and explain how the work will comply with the rules. Regional or district provisions and resource-consent conditions may also apply.

Mark asks not only, 'Can we build a road here?' but also, 'What could happen below this road if a control fails during heavy rain?'

BUILD, CHECK, ADAPT

Forestry road engineering continues after construction. Drains, culverts, flumes, sediment traps, road surfaces and stabilised slopes must be inspected and maintained.

Inspections are especially important:

- during construction;
- before forecast heavy rain;
- after significant rainfall;
- while harvesting and log cartage are underway;
- when signs of scour, cracking, slumping or blocked drainage appear; and
- before a road is closed or left between forest rotations.

A design that worked initially may need to be adapted. Debris can block an inlet, a culvert outlet can begin to scour, sediment controls can fill, or previously unseen groundwater can emerge from a cut face.
Effective forestry roading depends on observing these changes and responding before a small problem becomes a road failure or an environmental incident.

CURRICULUM LINKS

This case study provides an authentic New Zealand context that educators can adapt across several curriculum areas.

Curriculum area	Possible learning connections
Science	Soil and rock properties, forces and friction, water movement, erosion, sediment, slope stability and freshwater ecosystems.
Mathematics and Statistics	Gradient, percentages, angles, measurement, distance, volume, cost calculations and interpreting site data.
Geography and Social Sciences	Land use, catchments, environmental management, regulation, economic decisions and impacts on communities.
Agricultural and Horticultural Science	Sustainable land management, soils, water, primary production and environmental protection.
Careers education	Pathways into forestry, engineering, earthmoving, environmental planning, GIS, harvest planning and machine operation.



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FOREST GROWERS LEVY TRUST (FGLT)

The Forest Growers' Levy Trust collects the commodity levy paid on harvested wood material from forest growers and acts as the custodian of those funds. The Trust ensures the levy is invested in research, development, biosecurity, promotion and other industry-good activities that benefit New Zealand's plantation forest sector.