B7 Transport

Guiding principles

Access and equity: Programs to improve the health and infrastructure of remote communities often overlook transport systems, particularly roads. However, transport systems are particularly important for remote communities, linking and integrating them with the wider community and essential services.

Health and safety: Reliable transport is required to deliver food supplies and health and medical services. People need transport to cultural, traditional and entertainment activities, and to commercial enterprises. Transport is also required for emergency evacuations, disaster relief and maintenance services.

Environmental health: Planning for roads and airstrips needs to take account of issues such as culturally significant locations, and the preservation of local vegetation and drainage patterns. Building and maintenance work should be carried out to minimise disturbances due to dust generation.

Appropriateness: Access to transport is affected by geographic, seasonal and economic factors; proximity to existing transport systems; the number of people and quantity of freight to be moved; and access to fuel. If more than one transport option (land, air, water) is viable, the second or third option can be used to provide backup for seasonal and other disruptions.

Affordability: The cost of transport infrastructure, equipment, vehicles and fuel, and the costs to use and maintain vehicles (including cars, road trains, aircraft and watercraft) are much higher in remote communities than in metropolitan areas. Many communities have limited funds for infrastructure, and the cost of building and maintaining roads, aerodromes and barge landings is often prohibitively expensive.

Sustainable livelihoods: To ensure safety and minimum standards of living, communities should have access to a range of transport options (including transport via land, air and water). Planned maintenance schedules and appropriate use help to reduce costs.

Systems overview

In the *National Indigenous Infrastructure Guide*, the term 'transport system' refers to transport options: land, air or water. The term 'transport infrastructure' refers to the hardware and design options that a community needs to utilise these transport systems.

Typical transport system options available for Indigenous communities include the following:

- *Land (typical community infrastructure — roads)*
  - Roads and tracks in remote communities usually link to a cattle station road (funded by local government), then to a major arterial road (funded by local, state or territory government) and then to major towns, cities or capital cities via a highway (funded by state or territory governments or the Australian Government). Roads can also link remote communities to rail networks.
- *Air (typical community infrastructure — aerodromes)*
  - For passengers in remote communities, air transport can be an economically viable alternative to road transport. Air transport is the usual source of mail delivery, medical services (such as the Royal Flying Doctor Service) and emergency evacuations for remote communities.
- *Waterways (typical community infrastructure — barge landings)*
  - Heavy rainfall during the wet season and unseasonable downpours can isolate remote coastal communities from road and air transport, so waterway transport becomes the only option. Barges and other watercraft can transport food, fuel, people and heavy equipment. However, barges require appropriately designed landings, and access may depend on factors such as tides.

Current service delivery arrangements

Responsibility for transport systems depends on the size of the community.

In **major communities** (at least 200 people), a state, territory or local government authority is responsible for maintaining roads and aerodromes. Major communities are usually accessed via a highway.

In **minor communities** (fewer than 200 people), outstation resource agencies or community councils are typically responsible for maintaining roads, airstrips and barge landings. However, these organisations often lack the specialist capacity and funds for this work. One-off grants from the Australian Government are occasionally available to reconstruct aerodromes, barge landings or sections of access roads.

Relevant Australian standards and guidelines

Roads

- Austroads guides for road design
- ARRB Group transport research guidelines
- construction and maintenance procedures, and road specifications used by local governments or main roads departments are available from local governments, main roads departments and other resource agencies.

Aerodromes

Community aerodromes must comply with aviation standards. These include the *Transport Act 1983* and regulations, the *Aviation Transport Security Act 2004* and regulations, and the Civil Aviation Safety Authority (CASA) *Manual of Standards Part 139 — Aerodromes*. Physical feature data and pilot requirements are described in Air Services Australia publications.

CASA classifies aerodromes according to the types of aircraft and the aggregate aircraft weight that they can support; an aerodrome must comply with the standards for its particular classification. These standards include specifications for runway length, width, construction type and pavement type. For more information, see the CASA *Manual of Standards Part 139 — Aerodromes*, Chapter 5.

CASA requires aerodromes to be inspected regularly in accordance with their standards. Aerodrome owners are responsible for maintaining aerodromes to the standards of CASA and the Royal Flying Doctor Service.

Waterway landings

Barge facilities are regulated by the state or territory department that controls shipping movements. Owners and operators are responsible for maintenance.

Involving the community

It is essential that project managers and designers consult with the community before and during any transport infrastructure projects.

Roads

Ensure that:

- town plans and serviced land availability program (SLAP) maps are consulted during planning
- the community is informed about potential disruption, noise and site safety issues
- planning takes into account floods that occur once in 50 or 100 years
- elders are consulted about sacred or sensitive sites such as burial grounds
- contractors are made aware of local people who are skilled in any aspect of the project (such as plant operators) and may be available for short-term employment during the construction phase or later maintenance work.

Aerodromes

Location of airstrips will affect how nearby land is used, because aerodromes use a considerable amount of land. Therefore, community consultation is essential.

While the management of the aerodrome will depend on its classification, usually the owner or manager of the land is responsible for the governance of the aerodrome.

Ensure that:

- community members are involved in the decision-making process for aerodrome design and construction
- local knowledge is sought about weather patterns
- the location of heritage sites and sacred sites in the area is investigated
- suitable local sites for extracting gravel or other construction materials are identified, and access is negotiated with the owner well in advance
- where possible, local community members are trained to be aerodrome reporting officers (duties include daily, weekly and monthly inspections of the airstrip and associated equipment, instruments and communication systems).

Waterway landings

Waterways and sea access points are generally places of cultural significance and sites for community meetings or fishing.

Ensure that:

- cultural issues are discussed with the community before a location for a barge landing facility is selected
- community members are consulted about weather conditions, including storms, wind direction and tidal movements
- the community is engaged during the design of barge facilities (such as helping to gather readings such as wave action, tidal flows and tidal velocity).

Appraising community requirements

An accurate picture of the community's current and future transport needs and usage patterns is important when providing or improving access to a transport system, or when constructing or changing infrastructure. This information is essential for making decisions about the appropriate design, size, functionality, costs and capacity of the system.

Community

Consider how the following features of the community will affect the choice of transport infrastructure:

- population profile and demographics (including permanent and mobile populations, seasonal variations in population size, and the number of infants, children, teenagers, adults and the elderly)
- employment, enterprise and education levels (including capacity to pay for transport and freight)
- community plans and aspirations for the future (including the community business plan), particularly planned or expected population growth or decline over the next 5–10 years
- community attitudes to transport systems (fear of light aircraft or rough waterways).

Current status of transport infrastructure

Consider:

- potential obstacles to reliable transport to main supply centres, such as flowing rivers and creeks, rough or dangerous waterway conditions, fallen trees or vegetation regrowth on aerodromes
- the reliability and capacity of current transport infrastructure and supply arrangements
- community use of and satisfaction with current infrastructure and supply arrangements
- cost of each transport option, including freight and fuel costs (note: fuel costs include the cost of transporting fuel for uses within the community such as power generation and the cost of fuel for the transport vehicles themselves)
- service and maintenance needs of the current system (check logbooks and system financial records and check, maintain and download traffic counters)
- current maintenance arrangements (including the service regime and funding for planned maintenance)
- ownership of current transport infrastructure
- current system configuration and design, including capacity for upgrades.

Community transport service needs

Consider:

- accessibility of the community via land, air and waterways
- prevailing climate of the area and potential climate change
- transport requirements associated with institutions and infrastructure in the community (such as police station, schools, clinic, store, workshop, service station, water supply, communications and sewerage system)
- transport needs of commercial activities in the community
- access to medical services and likely need for emergency evacuations.

Quantifying a community's transport needs

It is good practice to carry out a transport audit to assess a community's transport needs and available options. All services that depend on transport should be considered in the audit.

Community members should be involved in the audit process as much as possible to ensure that accurate records of use and estimations of current and future transport needs are made.

Consider surveying, calculating or estimating:

- the annual transport pattern for people entering and exiting the community (consider patterns associated with people buying food and other supplies, accessing medical services and attending funerals, cultural activities and entertainment)
- average daily, weekly, monthly and annual use of transport systems (including patterns of use, such as weekly mail plane, monthly delivery of powerhouse fuel and monthly medical service)
- transport patterns associated with school children (including school buses and private vehicles)
- the average number of people evacuated for emergency medical treatment (include Royal Flying Doctor Service and local health clinics)
- annual tonnages of freight for food supplies, spare parts and other stores
- annual tonnages of freight for transporting powerhouse/generator fuel
- annual mail delivery requirements
- annual requirements for transporting service crews to repair and maintain essential services
- peak passenger loads or maximum freight tonnages for the various transport systems (such as road trains carting fuel, cattle, building materials, transportable homes; barges carrying heavy equipment or building materials; aircraft carrying people and freight; and specifications required by the Royal Flying Doctor Service for aerodromes).

Policy

Consider:

- contacting your local government representative or Indigenous Coordination Centre for information on current state or territory policies on providing transport to Indigenous communities.

Reliability

Consider:

- how reliable access has to be (for example, Royal Flying Doctor Service access and medical services to the community).

Costs

There can be huge differences in capital outlay for all aspects of transport, ranging from relatively low cost to millions of dollars. Security of appropriate levels of capital funds and of recurrent funds for preventive/planned maintenance are key factors in deciding which transport system(s) will best suit your community.

Funding

Bringing earthmoving plant and equipment to remote communities is expensive, so it is important to consider whether other nearby communities or municipal services may also require the use of equipment so that costs can be shared.

Consider:

- the level of funding currently available
- sources of funding currently available
- specific types of projects for which funding is currently available.

Recurrent/ongoing costs

Consider:

- rebates (such as diesel used in road maintenance or construction)
- the duration of funding commitments (for example, whether recurrent funding will be available for the expected life of the system).

Cost recovery

Consider:

- existing cost-recovery mechanisms that may help to meet operating costs (such as rates, levies and tariffs, and landing fees)
- whether operating cost subsidies are available
- which organisations have the capacity to collect rates, levies and tariffs (for example, local government or road utilities)
- whether the community is large enough to have the administrative resources to manage cost-recovery arrangements.

Servicing and support

Consider:

- whether the community has access to servicing networks and adequate resources for maintaining transport infrastructure (for example, earthmoving equipment)
- whether community members themselves have the technical skills to maintain transport infrastructure (such as accreditation to operate earthmoving equipment)
- existing support structures to allow the community to operate and maintain transport infrastructure.

Distance and proximity

Consider:

- the distance from the community to major transport systems, regional centres, fuel supplies and maintenance services — providing reliable transport services to remote communities can be difficult and expensive (for example, long roads between communities in remote areas often require river or creek crossings, cost more to maintain and require more time to recover from flooding)
- seasonal changes to accessibility (for example, communities that are inaccessible during the wet season require large fuel stores for maintenance vehicles, and inbuilt redundancy to allow for longer maintenance response times).

Climate and geography

Many remote Indigenous communities in the Northern Territory, Queensland and Western Australia are located in areas with a range of extreme climates. Climate is an important factor to consider when designing, constructing and planning maintenance for transport systems and infrastructure. For example, in tropical zones the extended wet season can reduce access to external resources, so maintenance must be carefully planned. Systems should also be designed so that damage from flooding is minimised.

Geographical considerations include the likelihood of flooding and proximity to the ocean. All roads and creek crossing structures must meet appropriate stormwater loading standards and codes. Marine environments can be particularly harsh on materials.

Consider:

- the location of the community and the prevailing geographical and climatic conditions (such as cyclone, tsunami, seawater, extreme temperatures)
- whether scientific modelling is available on the likely effects of climate change
- variations in maximum transport loads according to seasons.

Environmental concerns

Every transport solution will have different environmental impacts.

Consider:

- noise
- exhaust fumes
- fuel type and consequent greenhouse impact
- visual impact.

Cultural issues

Consider:

- the location of sacred sites — inappropriate development on culturally significant land is unacceptable to community members; an initial consultation can avoid costly changes later
- the likelihood of restricted site access at certain times due to ceremonial activities — every system type requires both regular scheduled maintenance and unscheduled access for repairs, so restricted access can mean extended downtime or potential costs associated with major repairs due to poor maintenance.

New technologies

Transport technologies improve in small increments over time, and such improvements often go unnoticed. 'Dust control' is an example of a new technology that is cost-effective and offers potential health benefits and improved reliability. However, new technologies that have not been thoroughly tested in appropriate environmental conditions should not be installed in a remote Indigenous community. For example, many government-sponsored tests have demonstrated the short-term benefits of dust-control agents, but bitumen seal is still cheaper when all life-cycle costs are considered.

Consider:

- whether new transport technologies are available
- whether new technologies are appropriate for use in Indigenous communities.

Choosing appropriate solutions

There are two sets of choices to make when considering community transport options:

- Choosing the transport option or options (land, air, water) most appropriate to the community — in most cases, access to these will already will be in place, dictated by geographical factors, proximity to existing major transport systems (such as national highways, ports and major airports), the size of the community, and the number of people and amount of freight and fuel to be transported.
- Choosing the most appropriate type of transport infrastructure — informed decisions about transport infrastructure need to be made, such as
  - what type of road to build or upgrade (for example, whether it should be sealed or unsealed, how wide and what materials)
  - what standard of aerodrome (length, sealed or unsealed) is appropriate
  - what infrastructure (floating pontoon landing, concrete barge ramp, etc) is required to land the barge or ferry at the waterway.

If no transport system is readily available (because of proximity, seasonality, economic or other factors) a range of influencing factors should be considered and the community's transport demands quantified before a final decision is made. The implications of each factor are explored in Figure B7.1, which can be applied to land, air and waterway transport systems and infrastructure. Much of the information relating to these factors will have been collected during appraisal.

Figure B7.1: Factors to consider when choosing a transport system

Quantified community transport system demand

Survey/assess total range of community transport demands

Measure, calculate and consider the nearest/most economically viable options for accessing transport systems (land, air, waterways)

Assess and consider community acceptance of the viable transport system options

Arrange for costing analysis for providing reasonable access from the community to the transport system option/s

→

Influencing factors

Policy

Financial considerations

Service and support

Distance and proximity to existing systems, such as road/ rail, airports, waterways

Reliability

Climatic/ geographical

Environmental

Cultural

Growth

Existing infrastructure

Physical land availability

Emerging technologies

→

Informed choice

Based on assessment of need and consideration of other issues to decide the most appropriate supply solution

→

Transport system

Land and transport options (rail or road)

Air and transport options (size and type of aircraft)

Waterways and transport options (barge, small boat, ferry, etc)

Source: Centre for Appropriate Technology, 2009

Roads

Roads are classified using formation types or standards:

- kerbed and bitumen-sealed formation internal roads
- bitumen-sealed formation access roads
- type 3 gravel formation access roads (unsealed)
- type 2 formed formation access roads (unsealed)
- type 1 flat-graded formation access roads (unsealed).

A bitumen-sealed formation access road is usually the best choice in terms of lifespan, dust control, environmental health and accessibility. In particular, community council workers, service providers and funding agencies should aim to have community internal roads kerbed and bitumen sealed. However, bitumen-sealed roads are expensive, so for community access roads that connect with other communities or major transport systems, the most likely choices are the various types of unsealed roads.

Materials

Locally sourced materials such as gravel will be required to construct, reconstruct and maintain transport infrastructure.

Gravel can be acquired from existing quarries and pits. The local government authority may require an extractive industries permit where quarry industries are already in place (such as excavation works and crushing plants). Australian Government and state and territory government departments will need to give clearance for all gravel sources, including environmental clearances (for issues including wildlife protection and waste and noise minimisation) and heritage clearances. Royalties may also need to be paid to the owner of the land where gravel is sourced.

Each geological area will have different material types that can be used for different construction tasks. Material may also be brought from other locations.

When a gravel pit or quarry is exhausted, the site must be rehabilitated by levelling, covering with topsoil and revegetating using native grasses and plants. If the pit is on a cattle station, the pit may remain as a dam or water source for stock; requirements should be discussed with the station management.

Roadside furniture

Roadside furniture includes signs and devices to warn users of hazards, and to control water, traffic and stock. Appropriate roadside furniture can enhance road accessibility and safety.

Consider:

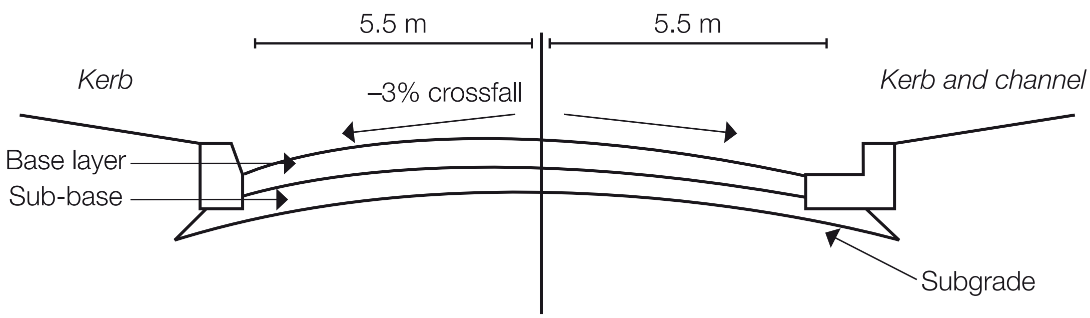
- river and creek crossing designs
- road drainage (see Chapter B2 Stormwater for information on culverts, pipes and drains)

- stock control (including fencing, cattle grids and gates)
- traffic control (including gates and signage).

Kerbed and bitumen-sealed formation internal roads

Kerbed and bitumen-sealed formation roads are preferred for a community's internal roads (Figure B7.2). If properly maintained, these roads can last 10–15 years. Construction of kerbed and bitumen-sealed roads is expensive, but if the correct design and construction techniques are used, asset maintenance costs will be reduced.

Figure B7.2: Kerbed and bitumen-sealed formation access roads



Source: Centre for Appropriate Technology, 2009

Appropriate design and construction

If a community is fortunate enough to have funding for internal kerbed and bitumen-sealed formation roads, a skilled project manager should be employed to oversee all aspects of design and construction.

The design and construction of kerbed and bitumen-sealed formation roads is a specialist job — from accurate survey of the landfall, to the design, then preparation, formation, compaction and sealing of the road. Final finishing requires precision graders and operators, which are not usually available within a community.

Bitumen does not absorb water, so bitumen-sealed roads require stormwater drains. There are many possible options for internal road stormwater drainage — professional surveys should be conducted before a choice is made (see Chapter B2 Stormwater for more information on drainage).

Maintenance

Maintenance should be planned and budgeted for each year. Bitumen reseals will be required every 8–15 years, depending on the rate of deterioration. Failure repair procedures are available from local governments, local resource agencies and main roads departments. The type of failure and the amount of area affected will determine the rate of deterioration and will inform maintenance cycles.

Building a dataset over a period of years will help to determine the rate of deterioration for each community's road network more accurately; this will allow more accurate budgeting.

Ensure that:

- streets are swept at least once a year or, in northern Australia, after the wet season or other downpour — sand, silt and rocks on the road surface can cause damage to the bitumen seal; some communities own streetsweepers or tractor-drawn brooms, or local contractors may hire them
- potholes are repaired as soon as they appear, and are repaired before the wet season — pre-mix (bitumen), a compactor (often known as a 'wacker rammer') and shovels are required
- cracks in the bitumen surface are repaired as soon as possible — these appear on a regular basis and are repaired by pouring tar into them to reseal the surface and protect the sub-base from becoming damp
- 'patching' is carried out where larger sections of bitumen surface have failed — this type of repair requires specialist equipment such as a small ride-on roller, and perhaps a bitumen truck to spray and lay the new surface.

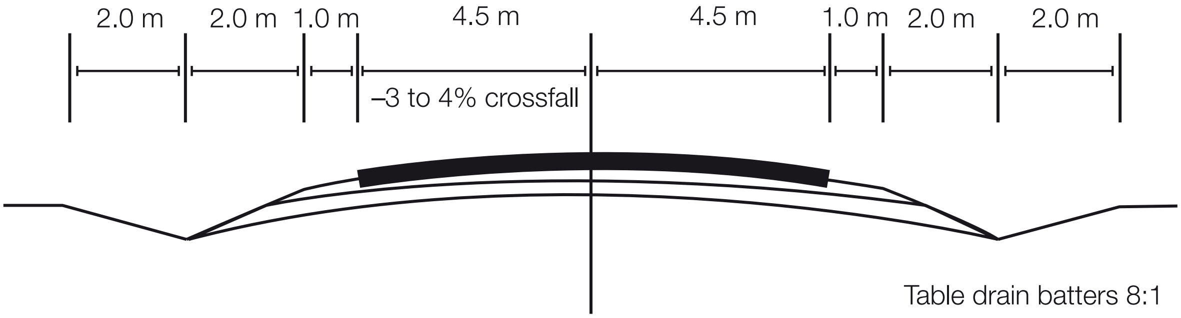
Bitumen-sealed formation access roads

Remote communities are unlikely to construct a bitumen-sealed formation access road (Figure B7.3). In most cases, funding for these roads would include state, territory or local government authorities accepting responsibility for construction and maintenance. Bitumen-sealed formation access roads have similar requirements to kerbed and bitumen-sealed formation internal roads, except they have greater width and load ratings.

Ensure that:

- shoulder damage is repaired — this is a common failure along the edges of a bitumen road (where kerbing is not installed), which can rapidly cause deep erosion; damage should be 'boxed out' to an even depth and width, filled with pre-mix and compacted.

Figure B7.3: Bitumen-sealed formation access roads



Source: Centre for Appropriate Technology, 2009

Type 3 gravel formation access roads (unsealed)

Type 3 gravel formation access roads (Figure B7.4) are best when bitumen seal is prohibitively expensive for the funds available and the volume of traffic carried. Type 3 earthworks are constructed using tested and appropriate imported road materials — shaping, sheeting and compacting suitable gravel to an appropriate thickness, and ensuring proper drainage. This kind of road design may be used for new roads, but is often the result of upgrading previously existing tracks or roads. It is a viable solution if the previous road was too expensive to maintain, or if there would be economic or social benefits to improving the road.

Figure B7.4: Gravel formation access road

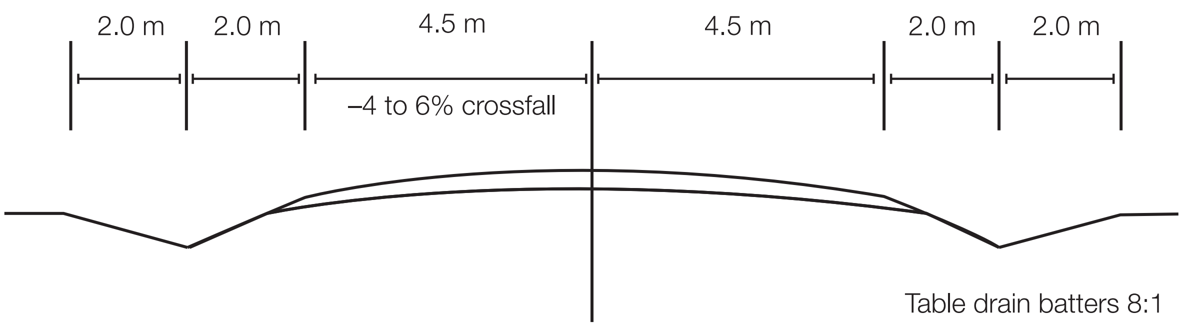
Source: Centre for Appropriate Technology, 2009

Appropriate design and construction

Appropriately skilled designers, plant operators and earthmoving contractors are essential for gravel formation road design and construction. These roads should be constructed to specifications appropriate for a bitumen-sealed formation road. Type 3 roads are formed using local material to create the formation — water is added to the local material and the surface is then compacted and trimmed to create a subgrade layer. A base layer of suitable imported gravel is then spread, compacted and trimmed to create a wearing surface for the road. A base layer depth of 150 millimetres will last eight years before requiring gravel re-sheeting.

Access road profiles are dependent on the amount and type of traffic. If the road is frequently used by large trucks (such as road trains or semitrailers) then the formation should be at least 15 metres wide (see Figure B7.5; further details can be found in the Austroad *Guides to Road Design*). Roads with less traffic and smaller, lighter vehicles can have smaller road formation widths and strengths.

Figure B7.5: Gravel formation road — typical dimensions



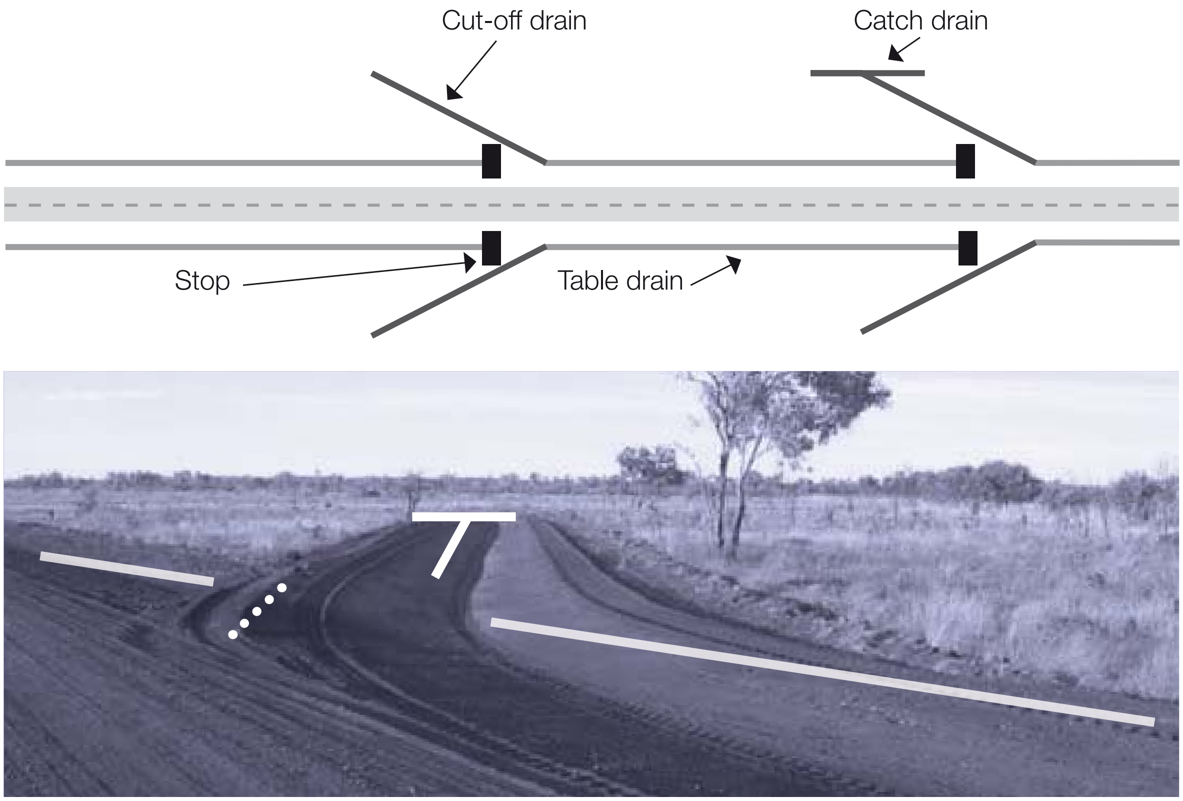
Source: Centre for Appropriate Technology, 2009

Stormwater considerations

If there is the opportunity to realign a road where experience has shown past problems with drainage or rapid breakup of the road surface, expert surveyors should be employed to survey the highest route possible to assist stormwater drainage. Safe curves can be designed at the same time.

Type 3 roads are expected to have appropriate drainage (Figure B7.6). Table and cut-off drains are mandatory, with catch drains required in areas where water cannot easily escape from cut-off drains. Stops are also important where cut-off drains leave the road on a downhill stretch of road, because they reduce the tendency for the water to scour table drains.

Figure B7.6: Typical stormwater drain system used for types 1, 2 and 3 roads



Source: Centre for Appropriate Technology, 2009

If a type 2 road is being upgraded, varying degrees of drainage will already be installed. Contractors must ensure that existing drains are cleaned during grading maintenance, before they are upgraded to type 3 standards.

For lighter traffic or smaller roads, single or one-way crossfall (the slope of the road surface across the road cross-section) can be considered to enhance road profile, drainage and easier grading techniques.

Ensure that:

- windrows (lines of mounded earth) are installed on the high side of the road where appropriate so that rainwater falling above the road and flowing downhill toward the road is caught by the windrow on the high side of the road formation, then diverted to the nearest cut-off drain, watercourse or culvert.

Maintenance

Maintenance grading of the formation and clearing of cut-off drains is essential to prolong the life of the road. Wherever possible, grading the formation should commence by cleaning table drains and cut-off drains, and the fines (fine material) washed away during rain should be returned to the pavement. Maintenance operators should strive to keep the pavement higher than the surrounding natural surface level of the land to improve drainage. This type of maintenance grading requires a high level of expertise.

The most economical method to maintain the road is to lay the material out in one layer and 'wheel' compact it as a single layer, trim the surface to profile, then remove any excess and surface rocks.

Ensure that:

- grader operators leave all material in the road running surface, including larger 'unwanted' rocks. The larger rocks give the pavement its strength; if the rocks are graded out of the road, it loses strength and the fines are easily blown away.

Type 2 formed formation access roads (unsealed)

The type 2 formed formation access road can be used when the community budget or grant is limited (Figure B7.7).

Figure B7.7: Type 2 — formed formation access road

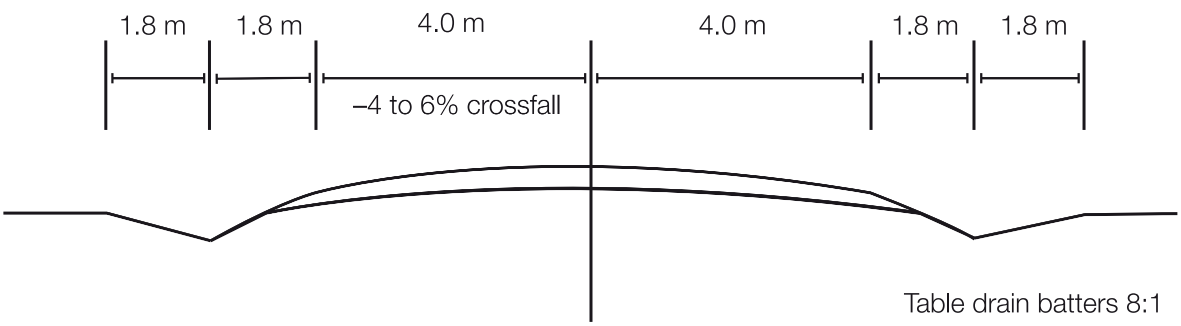
Source: Centre for Appropriate Technology, 2009

Type 2 formed formation access roads (Figure B7.7) are constructed using local road-making material, by forming up and compacting the running surface with a crown for improved drainage control. This also discourages traffic from seeking detours, helping to reduce erosion. Grader operators should attempt to maintain the shape of the crown, and keep stormwater drains open.

Appropriate design and construction

Appropriately skilled plant operators and earthmoving contractors are essential for formed formation road design, alignment (location of the road both horizontally and vertically in relation to the surrounding landscape and land features) and construction. Ideally, these roads should be constructed almost up to the standard of a gravel formation road. Formed formation access roads are constructed using local material — water is added, and the material is compacted and trimmed to profile as the main running surface (Figure B7.8). This formed and compacted surface should be at least 150 millimetres thick. With appropriate maintenance, it can last 8 years before requiring reforming.

Figure B7.8: Formed formation access road typical dimensions



Source: Centre for Appropriate Technology, 2009

Should the opportunity arise to re-align a road where experience has shown past problems with drainage or rapid breakup of the road surface, the highest route possible should be chosen to assist stormwater drainage. With appropriate supervision, a good team of operators and a contractor can construct this type of formation road without detailed design input; this will be cheaper.

Maintenance

Maintenance grading of formed formation access roads is similar to grading for gravel formation roads: clearing cut-off drains is essential to prolong the life of the road. Wherever possible, grading the formation should commence by cleaning table drains and cut-off drains, and the fines washed away during rain should be returned to the pavement. It is important that maintenance operators try to keep the pavement higher than the surrounding natural surface level of the land, in order to improve drainage. This type of maintenance grading requires a high level of expertise.

Type 1 flat-graded formation access roads (unformed road)

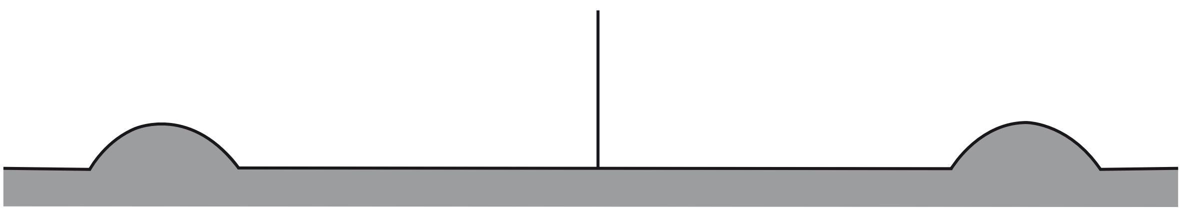
The type 1 or flat-graded formation access road design is the most basic of road types, and is used only where the community budget is very limited or where traffic is intentionally restricted, such as roads to sensitive or sacred sites, very small private outstations or fishing tracks (Figure B7.9). Constructing a new road of this type usually requires only a grader fitted with a bulldozer blade to clear trees and other foliage and vegetation, then normal grader formation of the road surface to a width of 6 metres (equivalent to two grader bladewidths).

Figure B7.9: Type 1 flat-graded formation access road

Source: Centre for Appropriate Technology, 2009

The cross-section of a type 1 road is shown in Figure B7.10. This road allows for only light traffic and is prone to closure during periods of heavy rainfall due to lack of drainage.

Figure B7.10: Flat-graded formation access road (unformed road) cross-section



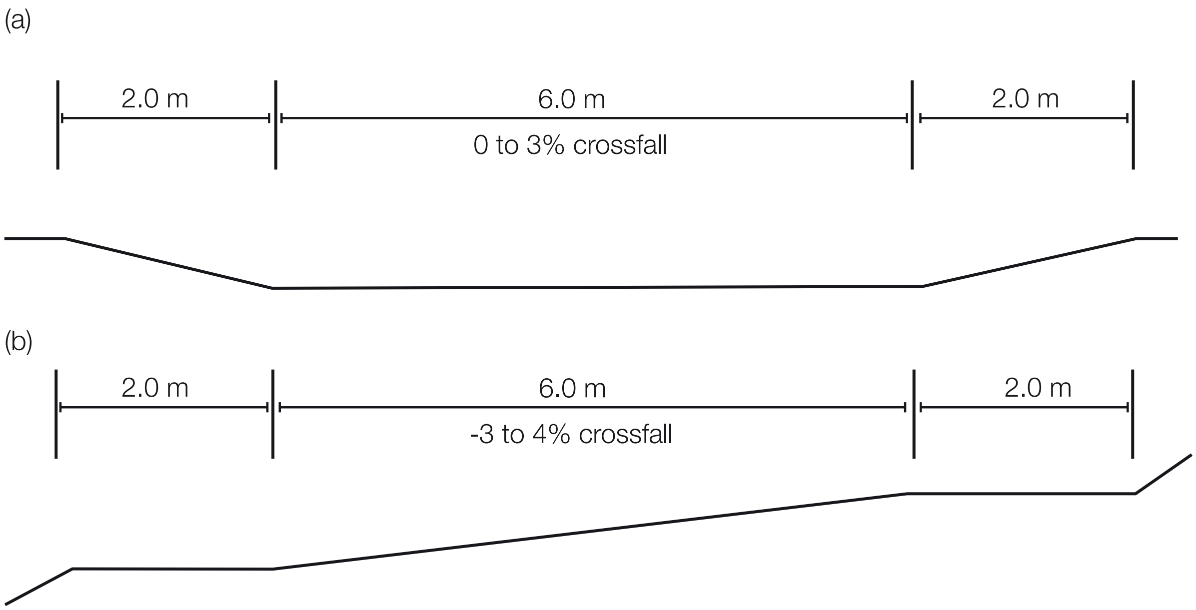
Source: Centre for Appropriate Technology, 2009

Appropriate design and construction

Grader operators with limited skills can successfully maintain this type of road; where possible, they should aim to cut some crossfall (slope across the road) or crowned top to aid stormwater drainage (Figure B7.11). Type 1 roads have the disadvantage that each maintenance pass with the grader cuts the surface deeper, increasing its vulnerability to flooding.

As with formed formation access roads, the highest route possible should be chosen to assist stormwater drainage. With appropriate supervision, a good team of operators and a contractor can construct this type of formation road without detailed design input; this will be cheaper.

Figure B7.11: Flat-graded formation access road: (a) on level ground and (b) on a slope



Source: Centre for Appropriate Technology (2009)

Table B7.1 gives some simple examples of possible community needs, options and approximate costs for road construction. Cost estimates are based on prices at June 2008 on similar contracts issued in the Kimberley area of Western Australia.

Table B7.1: Different road options for likely community scenarios

Requirement	Sealed[a]	Type 3	Type 2	Type 1	Construction (approximate cost per kilometre)	Maintenance (approximate cost)
To access a cultural site or fishing spot				✓	$140 plus any bulldozer clearing that may be required	$140 per kilometre per year
To access the community water supply, energy supply, landfill site or small nearby outstations			✓		$50 000–100 000	$250 per kilometre per year
To access a major arterial road or national highway, or for access between larger communities (can carry road trains)		✓			$80 000–110 000	$300 per kilometre per year
Community internal roads for access to housing and services	✓				$180 000–200 000	Sweeping $70 per hour Potholes $50 per square metre Reseal $10 per square metre Pavement failure $120 per cubic metre

a Kerbed, reconstructed gravel with bitumen seal.

Consider:

- recurrent costs for maintenance
- whether stormwater drainage will be required during construction and maintenance.

The reliability of unsealed roads is largely determined by the quality of maintenance.

Case study 14 — Choosing a safe, affordable access road

Every year, access by road between a remote outstation in the subtropics and its 'hub' community 38 kilometres away was cut off. The outstation had no airstrip and relied on the hub community for employment, schooling, stores, mail, clinic services, medical evacuation and maintenance of essential services. The access road was a rough, black soil, flat-graded track that quickly became impassable when wet. There was also a river crossing between the hub community and outstation. The community and outstation did not have appropriate earthmoving equipment for road construction, but they did have a grader that was adequate for regular road maintenance.

The outstation's resource agency was successful in applying for a grant to improve access between the outstation and the hub, so they appointed a project manager (following a standard government procurement process).

The project manager was initially shocked by the high cost of using earthmoving plant and equipment from the nearest towns. After some research, the project manager concluded that the funds would allow the construction of a gravel road that followed the existing road, but no further works would be possible. The project manager discussed this with the community, and learned that the road was usually passable with care 6 hours after rain. However, the river often flowed for 3–4 days, making the river crossing too deep for vehicles to cross. The project manager concluded that the most beneficial improvement would be a better river crossing.

The project manager found that further funding was not available, so talked to the community about building a formed road (a lower cost option that involves forming up local natural surface materials and compacting the road running surface) rather than a gravel road, and constructing a simple river crossing. The outstation members agreed to this solution.

The project manager proceeded to scope the works required, to develop their design and specifications, and to seek estimates from contractors in the region with appropriate experience and earthmoving equipment. The tender included encouragement for the contractors to use local labour and operators.

The successful contractor constructed the access road to a good standard, using a local operator on his self-propelled roller. He also employed three local workers to assist with cementing work and consolidating the river-crossing surface with crushed rock. The contractor also trained a local grader operator in best practice for ongoing grading and maintenance of the new road.

Aerodromes

Many individual Indigenous communities, ranging from very small to large, own or share an aerodrome. The ideal design is one sealed with bitumen, and well-formed, with a slight crossfall or crown for drainage. Airstrips can be of varying dimensions, depending on registration or licence conditions, and the size and type of aircraft expected to use them.

Larger, sealed aerodromes are likely to have a large number of design requirements. They may have ‘furniture’ such as drainage systems with drains, culverts or drainpipes, fences and gates or cattle grids for stock control, a windsock, an aircraft hardstand area (an area where engines can be warmed without the danger of propellers or turbines ‘sucking’ up rocks), pilot-activated lighting for night landing, shelter and toilets for passengers, refuelling facilities for the aircraft, and signage for air and ground traffic control.

Sealed aerodromes require regular surface inspection and maintenance. They will sometimes require sweeping, specialised bitumen maintenance equipment and skilled operators.

Ideally, the placement of aerodromes within the region should be arranged so that the time taken to drive from each community serviced by a given aerodrome to the aerodrome is the same or less than the time taken for the Royal Flying Doctor Service to fly there from their base. This is not always the case, and road conditions and accessibility to the aerodrome can be a problem for injured patients.

Appropriate design and construction

Designing and siting an airstrip is a complex and important task; where possible a qualified airport technician should be employed to do this work. A new bitumen-sealed airstrip can cost up to $1.2 million for construction and an average of $60 000 per year to maintain; a community’s need for an airstrip must justify the cost.

Issues that the designer will take into account include:

- prevailing wind directions and speeds throughout the year
- geographical information (including the height of the surrounding country in a 25-kilometre radius)
- availability of suitable land to construct an airstrip of the required dimensions (the Royal Flying Doctor Service requires a strip 2.1 kilometres long and 30 metres wide)
- the need to clear obstructions
- stormwater and subsoil water flows, directions, volumes and velocities
- the required sizes for aircraft parking area, apron and taxiway
- accessibility of the airstrip from the community through all weather conditions
- availability of construction materials (preferably within 10 kilometres of the strip location)
- stock-proof fencing and security fencing around the perimeter of the aerodrome — including access points for emergency and passenger vehicles

- runway lighting requirements, including whether a pilot-activated lighting system is required
- communication systems for the pilot and ground personnel
- navigation aids
- whether bitumen sealing should be used; this will increase the initial costs, but reduce the maintenance costs
- sealing the shoulders, including the area around and between runway lights (for easier maintenance of the lights)
- requirements for CASA inspection of registered airstrips, and requirements for other airstrips to be inspected by a CASA-approved agent.

Maintenance and operations

Community aerodrome managers must understand the significance of the standards and the related maintenance required for their aerodromes (see ‘Relevant Australian standards and guidelines — Aerodromes’). Should aerodromes become neglected and an emergency occurs, aircraft operators or pilots may be unable to use the aerodrome safely, and they may refuse to land.

Ensure that:

- runway lighting is checked every week
- fuel-powered lanterns (such as kerosene lanterns) are full
- light bulbs work
- batteries are in good condition and are smart-charged (that is, trickle charged with charge level measurement — replace batteries every 6 months)
- solar powered lights are functioning
- hardwired lights are checked daily by manual switch or a control system (have an electrician check them every 6 months)
- permanent light fixtures (hardwired or solar) are painted around with black paint or bitumen (2 metre radius) to reduce the likelihood of damage by vehicles
- any maintenance on the runway is carried out within a 24-hour period, including slashing, repairs to lights, replacement of damaged gable markers (elongated markers at airstrip ends), cones, windsocks, other navigation aids and communication equipment — other aerodrome facilities should be repaired within a week
- gable markers and cones are repainted once a year and replaced every 10 years
- all people entering the airside area, including passengers and vehicle drivers, are aware of the regulations for approaching an aircraft
- operational procedures are followed

- daily checks are conducted, including fencing, airstrip and runway condition, airstrip grass height, lighting, communication system, windsock and signal circle (the circle surrounding the windsock), and navigation aids
    - every community aerodrome is inspected by a responsible officer on the day of any aircraft landing — aerodromes with a higher classification can be inspected by a qualified reporting officer, who records observations on a daily checklist.

Gravel formation airstrip runways

Maintenance

Gravel formation runways need to be graded at least once a year and the gravel re-sheeted every 8 years.

The airstrip must be cleared of all shrubs, trees and ant mounds, and the grass must be kept to a height that does not obstruct the pilot's view of the runway lights, gable markers and cones. The airstrip should be mowed regularly and the grass around the lights, gables markers and cones sprayed with herbicide regularly. The signal circle and windsock circle must be cleared and the ground painted black or sprayed with a black bitumen product.

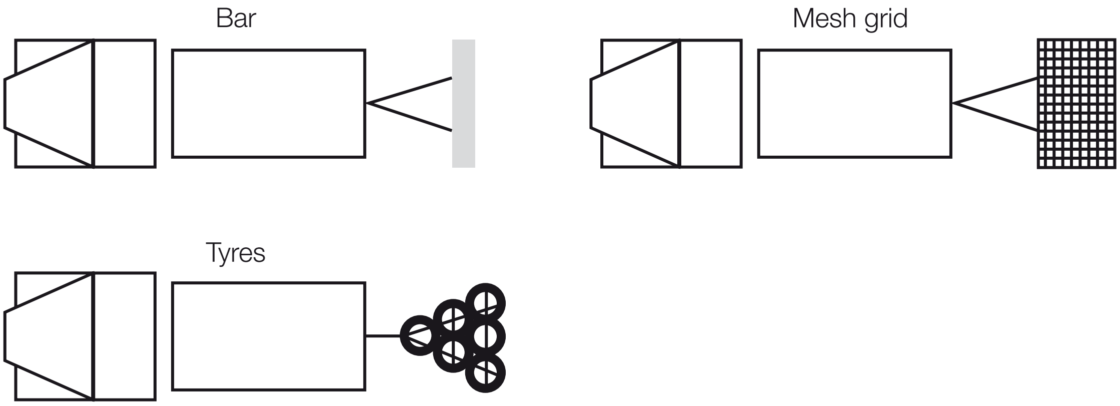
The windsock must be checked daily for damage and its bearings must be greased regularly to ensure it swings freely.

Ensure that:

- grader operators only perform very light maintenance to the runway landing strip
- the compacted surface is never broken or cut
- maintenance of the verges does not damage the runway landing strip, airport drainage system, or fencing
- revegetation is controlled with a light tractor and slasher immediately after the wet season in tropical and subtropical regions, and as regularly as required to ensure that it does not grow beyond the capacity of a tractor and slasher.

An affordable alternative to a grader for remote communities is a tractor towing a drag (Figure B7.12).

Figure B7.12: Alternative airstrip maintenance equipment — types of drags



Source: Centre for Appropriate Technology, 2009

Bitumen-sealed formation strips

Maintenance

Bitumen-sealed formation strips should be resealed every 10 years with two coats of seal — a 7-millimetre aggregate seal and a sand seal.

The reseal width should also include the area between the runway lights to prevent lights being overgrown by grass or damaged by equipment such as mowers and slashers. The area between the seal and the lights is often neglected because it is difficult to mow around small objects, so they become overgrown and invisible to the pilots. If the area between the lights is bitumen sealed, then the lights are always visible and less maintenance is required.

All runway markings should be repainted annually.

Bitumen-sealed formation strips should be checked every day for potholes or cracking in the bitumen seal, especially after electrical storms.

Case study 15 — Designing an airstrip

A small, remote community was located on a seasonally busy tourist route over 3 hours drive from the nearest major town and all-weather airstrip. The community asked for support from local, state and territory governments and the Australian Government, and local non-government support and resource agencies so that they could procure a grant for an airstrip. However, the community did not have the capacity to meet the complex requirements for a grant application. A local non-government organisation was asked to assist the community; and seed funding was provided to site and design the airstrip.

(continued)

The project manager soon established that the community was located on a small block of land that was previously part of a cattle station. The community produced a letter signed by the owner of the cattle station allowing the use of additional land for the airstrip. The project manager then investigated all of the necessary requirements (including approvals and clearances) and found the following:

- *The 'land-use agreement' with the cattle station had 'strings attached' such as ownership of the land (and therefore the airstrip), creating complex liability issues. The state agricultural authority needed to investigate the situation.*
- *The airstrip was to be used by the Royal Flying Doctor Service, meaning the community would have to tender for and procure a licensed airport technician to design and site the airstrip.*
- *A sensitive cultural site further restricted land access to the airstrip. Clearance was therefore required from the state environmental protection authority and local Indigenous land council.*
- *The site was close to hills and ranges, so limited area was available for correct orientation of the airstrip to meet Royal Flying Doctor Service requirements for night landing.*
- *A main road easement restricted the correct siting/orientation of the airstrip.*
- *Royalties would have to be paid to the local landowner for gravel for the construction of the airstrip.*
- *The community needed to agree to provide access to water for the airstrip construction from a local creek.*

The project manager then set about accessing the funds for the construction of the airstrip, applying to several state government and Australian Government departments because funding for the full amount was not available from a single agency. Sources included the state government department overseeing aerodrome development schemes and the Australian Government department overseeing flood mitigation support. Other state government department stakeholders in the proposed airstrip included the main roads authority, tourism authorities, police, health services, essential services and maintenance providers.

Water landings

There are many remote communities on islands, peninsulas or in tropical areas where flooding of roads and river crossings during the wet season limits access or isolates them from the mainland or regional centres. Generally, the only remaining access is either by aircraft or by watercraft, such as barges. While aerodrome and aircraft size will limit the amount of cargo to these communities, a large coastal barge or ship will increase the volume of freight that can be transported in a single trip.

Barge landings

The most basic landing is a graded ramp from the natural surface level of the access road down to the water level, where the tide level is sufficient to land the barge or other regular watercraft safely. The ultimate designs are non-slip concrete slabs, concrete block mats or other prefabricated materials.

Floating pontoons

Occasionally a floating pontoon landing may be an option, depending on factors such as the type of watercraft used and the depth of landing areas.

Appropriate design and construction

A barge landing is an important item of infrastructure that requires specific design and maintenance techniques. Professional marine engineers should be employed to investigate, design and construct a barge landing facility. They will require measurements of the barge draft and the manufacturer's specifications for the barge.

To support the barge landing facility, the community layout plan should include:

- potable water
- fuel facility — storage for incoming fuel and/or fuel for the barge
- electricity for storage sheds
- secure areas, including hardstand berths
- loading and unloading equipment — forklifts and/or prime movers
- truck(s) to deliver the goods from the barge to the end user.

The town plan or layout plan should show any future industrial development and access points to and from the barge facility.

Ensure that:

- the hardstand area will not be affected by poor weather, if the barge facility is the only form of access available at these times.

Maintenance

The most likely causes of failure of barge landings are concrete corrosion and damage from rough landings. Maintenance to a barge landing requires professional input to the scope of works and methods of repair, and only experts should be employed for these tasks.

Ensure that:

- the landing is clear of floating debris (such as logs) before barges are landed
- assistance is available for landings in rough weather.

Useful terms

Alignment	Location of the road both horizontally and vertically in relation to the surrounding landscape and land features.
CASA	Civil Aviation Safety Authority — www.casa.gov.au
Crossfall	The slope across the road cross-section of the top of the road surface.
Draft	Depth of water displaced by a boat or ship.
Fines	Fine material in road surface.
Gable markers	Elongated markers at the ends of airstrips.
Hardstand	A hard-surfaced area for parking aircraft, boats or vehicles. Aircraft: an area where engines can be warmed without the danger of propellers or turbines 'sucking' up rocks. Water vessel: a berth or mooring area.
Signal circle	The circle surrounding the windsock.
Transport infrastructure	The hardware and design options that a community needs to utilise a transport system.
Transport system	A generic term for any of the three broad transport modes or options: land, air or water.
Windrow	A line of mounded earth.

Further reading

Air Services Australia: www.airservicesaustralia.com

ARRB Group publications:

- *Sealed Local Roads Manual: Guidelines to Good Practice for the Construction, Maintenance and Rehabilitation of Pavements*, revised and expanded edition (2005)
- *Unsealed Roads Manual: Guidelines to Good Practice*, 3rd edition (2009).

Austroads guides to road design:

- AGRD01/06 : *Guide to Road Design — Part 1: Introduction to Road Design*
- AGRD02/06 : *Guide to Road Design — Part 2: Design Considerations*
- AP-G1/03 : *Rural Road Design — A Guide to the Geometric Design of Rural Roads.*