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Technology transfer: the role played the United States Bureau of Reclamation in the development of the Snowy Mountains Scheme

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THE ROLE PLAYED BY THE UNITED STATES BUREAU OF
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MOUNTAINS SCHEME

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Ross Dill, B.A.
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DECLARATION:

This work has not been submitted for a degree to any other University or Institution.

R. W. Dill
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ABSTRACT:

Technology permeates and is an integral part of the whole social, economic, cultural and political fabric of society. The state of the technology which exists at a particular point in time is, amongst other things, the product of many individual decisions and preferences by governments, industry, individuals and the community. Whilst some technology involves substantially new developments, much of it is evolutionary and occurs largely out of sight.

The same is true of the process of Technology Transfer which at its most fundamental level involves the movement of knowledge across boundaries. The processes and methods of technology transfer vary according to the type and nature of the technology to be transferred. During any transfer process however a number of factors may be involved either dependently or independently, these include people, organisation structure and culture, and the economic and political environments.

The Snowy Mountains Scheme, a dual purpose hydro-electric and irrigation complex, widely regarded as being one of Australia's greatest engineering achievements, provides an example of the transfer of technology from one country to another. The Scheme as it was finally constructed was first suggested in 1926 though no firm action was taken until 1948 when a joint committee comprising representatives of the Commonwealth, New South Wales and Victorian Governments confirmed the viability of a dual purpose scheme. The Snowy Mountains Hydro-electric Authority was created by an Act of Federal Parliament in 1949 and was charged with the responsibility of constructing the Scheme.
It is argued that neither the technology nor the resources necessary for the planning and construction of the Scheme were available in Australia at that time, and that without the assistance of the United States Bureau of Reclamation (U.S.B.R.) the commencement of the Scheme and its subsequent development would have been significantly delayed. It is further argued that this assistance was a form of technology transfer with the U.S.B.R. transferring to the Snowy Mountains Authority (SMA) and thus to Australia, technology in the form of hydro-electric and irrigation concepts, designs and work practices. An examination of how and why this transfer took place provides insights into aspects of the technology transfer processes particularly within Government and Statutory Bodies.
INTRODUCTION

Technology when described in its widest sense includes a tool, technique or social organisation or process. It is also useful to think of technology in the following terms as argued by Jones:

"Technology is a perishable resource comprising knowledge, skills and the means of using and controlling factors of production for the purpose of producing, delivering to users, and maintaining goods and services for which there is an economic and/or social demand." (p.vi)[1]

Given these comments, technology permeates and is an integral part of the whole social, economic, cultural and political fabric of society.

There is no optimal technology in an absolute sense [2]. The way to organise some purposeful activity is best or better relative to a particular complex of resources that are to be organised and to the particular circumstances in which the activity will operate. Indeed the state of technology existing at any one point in time is a product of evolution over time within the economic, social and political environment [3]. It is also the product of many individual decisions and preferences by governments, industry, individuals and the community and the multiple interactions between these preferred choices.

In dealing with technology there is a tendency to consider it only in terms of the visible and distinctive peaks, the wholly or substantially new product and processes, and to ignore the mass of evolutionary technological change which proceeds spontaneously and largely out of sight. [4] There is a similar tendency to focus on a single element or factor such as foreign ownership or capital inflow, and to be myopic about the myriad of other issues that play a part in technological change and technology transfer. In this regard it must be remembered that technological change is often a
cumulative process [5] and each extension of knowledge and each new solution to a technological problem creates the potential for further change. The development of this potential does not take place automatically however, and requires considerable human effort and commitment of resources. That is to say that whilst the application of rational principles to the control and re-ordering of space and matter is central to technology it should not be forgotten that these processes are concerned with human ends.[6]

Not only does the development of new technologies require effort and commitment but so too does the transfer of technologies from one area to another. Just as there are a large number of definitions and models of technology, some of which stumble into the methodological pitfall of reification of technology as an object[7], whilst others suffer from a single deterministic approach, so too there are a large number of models of technology transfer which emphasise differing aspects of the writer's individual frames of reference.

Rather than become embroiled in argument over a precise definition of technology transfer it should be recognised at the most fundamental level that we are dealing with the movement of knowledge across interfaces while keeping in mind that there may be important distinctions between specific sub-elements within such a general framework.[8] As there appears to be no single best method to analyse the transfer process so too there appears to be no best method for analysing the phenomena which comprise the transfer process.

Transfer processes and methods in technological change involve a wide range of factors including but not confined to people[9], organisational, struc-
tural and political aspects. Once it is recognised that there is no one best method to achieve technology transfer it becomes necessary to ask how did the process take place and why. Technology is moved by people: it does not move of its own accord. It is not a black box which can be shifted at will from one situation to another.[10] To adopt the transfer process efficiently to accommodate such changes calls for the removal of unnecessary constraints on communication among participants, and therein lies the strength of Burns' (1966) statement that "technology transfer is a process of agents not agencies". [11]

Individuals can fulfil both formal and informal roles. Formal agents include liaison or transfer officers whose major function is to promote transfer and who operate at the interface between their own organisations and potential receiver organisations. This model is based on the use of agents within the US Agricultural Extension Service of the late nineteenth century. [12] Whilst formal agents can be used as mechanisms to encourage and facilitate technology transfer processes, their success is dependent on their ability to act as the interface between the source of technical assistance and the potential customer. Informal agents are any of the myriad of people involved at different levels in the transfer process but who may not have been given or assumed the formal role of transfer agents. In situations where the technology to be transferred is so complex or novel that only the innovator fully understands it and its potential, agents who lack close knowledge of the technology may not be aware of the difficulties in achieving an appropriate contextual fit in a new environment and thus are not able to positively assist in the transfer process.

The level and type of communication about the technology also affects
its successful transfer. Certain types of information can only be effectively exchanged by face to face communication, for whilst the distribution of documentation may ensure a minimal level of awareness, it is the combination of documentation and personal interaction which enables the level of communication necessary for effective transfer to be achieved.

As with communications, the motivation of both individuals and organisations can have significant effects on transfer. Motivation is most often thought of as operating at the level of the individual however there is a corresponding level of receptivity which operates at the organisational level and which also affects the mechanism and success of technology transfer. Receptivity in an intra organisational sense, is a function of the perceived appropriateness of the particular technology. It is also influenced by the long term objectives and plans of the organisation.

Just as behavioural features influence the mechanisms and outcomes of technology transfer programs, so too do various aspects of the relationship between the technology producing, transferring and receiving organisations. There are formal aspects of this relationship, such as the contractual arrangements under which the technology transfer is carried out, and also the contextual ones which have their origins in the nature and abilities of the parties.

Personal contacts established through programs, courses, meetings and visitor services, all help to build up knowledge about and establish contacts important for effective technology transfer. Visits can ensure familiarity with latest techniques and therefore can transfer these back for application and modification of the technical or work practices.
Whilst strategic human resources are one of the prerequisites for successful transfer, others include the scientific and technical infrastructure, and international co-operation [13] including the role of the state.

The technology infrastructure or delivery system is the key linking network between the producers and users of technology. It functions amongst other things to bring perceived or articulated user needs to the attention of funders and research technology producers, and in turn delivers research results or technology to meet stated user requirements.

Technology delivery systems within industrialised nations have been broadly defined by four categories of participants according to Anyos [14]. These include "Funders or Entrepreneurs" which include public or private organisations that provide financial resources for the development or adaptation of technologies. In the USA this role is taken primarily by Federal Government agencies such as NASA, and large private sector producers such as IBM and General Motors. "Research and Development Producers" are found in both public and private sector organisations. These include government laboratories, universities, research institutes and private research and development activities. These may be funded either internally or via government processes. "Linking Agents or Brokers" are those public or private organisations or individuals that expedite the movement or diffusion of the technology within or across national boundaries. This category is said to comprise functional interest groups, professional organisations, trade associations, consultants, and any others who work to utilise new technologies on existing problems. In these cases it is the brokers role to identify applications within the public and private sectors, recognising that utilisation will almost inevitably involve
modification and adaptation to meet the expressed needs of the user. The final category of participants are the "Users". This group is broadly characterised by two generally different participants: those who benefit directly from the transfer of a given technology, usually the private sector, and those who benefit indirectly from the transfer, the ultimate user or consumer of the product of the technology.

In addition to the Anyos model of explaining infrastructure, it is argued that management forms an important part of the infrastructure because at the actual point of implementation of technology transfer, management which in the organisational sense is the process of utilising material and human resources to accomplish designated objectives, is essential.[15] Each individual project presents special problems and the choice and application of mechanisms such as human resources, organisation design and structure, use of contracts, transfer of patent rights and licencing, and the identification of technology brokers or "catalysts" can only be resolved and optimised at the working level.

Support for and through the technology infrastructure is only one of the ways that the state influences the transfer of technology. Young [16] speaks of government involvement as being either regulatory or non-regulatory. In the former, influence is through economic and legal frameworks including traditional micro economic measures such as fiscal policy, bank rates, credit policies, etc, taxation policies and Companies and Trade Practices Acts. Non regulatory measures may range from exhortation and voluntary agreement through the provision of advice and services [17] including consultancies, and government research establishments, to the development of a system
of financial inducements for particular types of developments such as regional policies, re-equipment schemes, and specific public support for certain industries and developments. Since at least the early 1940's the governments of all industrialised countries have been playing an increasingly direct role in the promotion and direction of their national industries. The role of promoter of technology is often assumed by governments because of the high risk and high costs involved in the development of new technologies.

It has also been argued that Governments resort to intervention as a means of prodding strategic parts of the economy [18]. Dell [19] has argued that the four major influences of the growth of these interventionist policies were the growth of international competition which eroded the basis of laissez-faire free trade policies, a feeling of economic failure especially following the depression of the 1930's, the increasing recognition of differences between private and social costs, and the emergence of specific social requirements that could not be met without the intervention of the state. This last group comprises such diverse aspects as education, deployment of labour, and provision of energy [20]. The role of government in promoting economic growth and limiting the simultaneous social disbenefits has become a central plank in modern industrial society [21].

The role of governments in promoting technological innovation including transfer is also a political one. According to Wells [22], the spectacular achievements arising from the application of science and technology in the 1940s in the USA led to major innovations which in a very brief period of time resulted in the creation of new industries, the restructuring of some and the demise of others.
In the American aerospace, electronics, nuclear and petrochemical fields vast new complexes of industrial, government and university research centres were established as the result of political decisions by Presidents Roosevelt and Truman to extend the Government's responsibilities for science beyond merely their establishment but rather to couple science and government to serve the national interest. This promotion of technology in particular sectors in order to realise various national goals should not be seen in isolation however for not only is technology used to fill defined needs, but social needs and values are themselves built and shaped by technology. The success of government collaboration with science during the 1940s led to increased government support of scientific enquiry which represented a major institutionalisation of science and technology as a formal tool for achieving government policy and corporate development [23].

The transfer of technology cannot in most cases serve as a substitute for industrial research and development [24]. Certain of the most advanced technologies cannot be learned in a formal way, and can only be absorbed in laboratories, similar to research and development activity. Bought technologies require adaptation to local conditions or products, and this adaptation generally though not always requires research and development. Additionally the absorption of new technologies requires early preparation, and the establishment of a capability able to develop its know-how towards the new field.

Whilst the establishment of research and development laboratories and facilities are generally associated with private industry, it is no less true of technology transfer to government departments and agencies. However, for transfer to be successful in the government sector an understanding
is required not only of the problems faced by the private sector but also of the overall problems and issues with which the government is faced.

A basic requirement for successful technology transfer is that the source possess technical knowledge and/or capability which could be useful to the receiver [25]. Additionally the source must understand the needs and limitations of the receiver. The receiver on the other hand should have complementary knowledge and capability, should understand the circumstances and potential contributions of the source, should demonstrate interest and support this with its own incentives. If these conditions are met, and if there is mutual confidence between the source and the receiver, then the way will be open for successful technology transfer.

An example of the process of technology transfer is provided by the relationship between the United States Bureau of Reclamation and the Snowy Mountains Hydro-electric Authority. Whilst the role of the Commonwealth Government is well known, little has been said of the role of the State Governments of Victoria and New South Wales, and even less about the role played by the Bureau with respect to the Snowy Mountains Scheme through the provision of technical assistance, technical advice in both the USA and Australia, and the training in America of Australian engineers by the Bureau. An examination of the roles of both sender and receiver of technology should therefore provide insights into the involvement of people, the infrastructure and the government in the process of technology transfer.
A GENERAL DESCRIPTION OF THE SNOWY MOUNTAINS SCHEME

The Snowy Mountains Scheme, a dual purpose hydro-electric and irrigation complex established by a Commonwealth Act, is located in south-eastern Australia. It impounds the south flowing waters of the Snowy River and its tributary, the Eucumbene, at high elevations of the Great Dividing Range, and diverts them inland to the Murray and Murrumbidgee Rivers through two tunnel systems driven through the Snowy Mountains. The Scheme also involves the regulation and utilisation of the headwaters of the Murrumbidgee, Tumut, Tooma and Geehi Rivers.

These diverted waters, in conjunction with the regulated flows in the Geehi and Tumut River catchments, generate mainly peak load electricity for the Australian Capital Territory and the States of New South Wales and Victoria, as it passes through power stations to the irrigation areas inland from the Snowy Mountains.

The Snowy Mountains Hydro-electric Scheme as finally constructed involved the investigation, design and construction of 16 large dams and many smaller diversion structures, some 80 kilometres of aqueducts, over 145 kilometres of tunnels, a pumping station and 7 surface and underground power stations. Its total generating capacity is 3,740,000 kilowatts and, through diversion, regulation and control of the rivers, an additional annual equivalent of 2,360,000 megalitres of water is made available for irrigation purposes in the Murray and Murrumbidgee Valleys.[26]

Broadly the Scheme falls into two sections: the southern Snowy-Murray development, and the northern Snowy-Tumut Development. Both developments
are connected by tunnels to the Scheme's main regulating storage, Lake Eucumbene on the Eucumbene River.

Figure 1. Cross sectional view of the two developments of the Scheme

The Snowy-Murray Development involves the diversion of the Snowy River by a transmountain tunnel system to the Geehi River and thence to the Swampy Plain River, a tributary of the Murray. In passing through the tunnel system the diverted waters fall some 820 metres, generating 1,500,000 kilowatts in Murray 1 and Murray 2 Power Stations.

Additional power is generated in Guthega Power Station which utilises the rapidly falling water of the Upper Snowy River on the east of the Divide before it reaches the main tunnel system at Island Bend.

An essential part of this development is the two-way-flow Eucumbene-Snowy Tunnel which connects the Snowy River with Lake Eucumbene. When
the flows in the Snowy and Geehi Rivers exceed the needs of the Murray power stations, water from the Snowy River at Island Bend is diverted through this tunnel for storage in Lake Eucumbene. Low flows in the Snowy and Geehi Rivers are supplemented by drawing the stored water from Lake Eucumbene back through the same tunnel and delivering it to the transmountain tunnel system leading to the Murray power stations.

Additional water is supplied to the transmountain tunnel at Island Bend by the Jindabyne Project which pumps from Lake Jindabyne the run off from the Snowy catchment downstream of Island Bend.

The Snowy-Murray Development provides 980,000 megalitres of additional water annually through the enlarged Hume Reservoir to the Murray River for irrigation in the Murray Valley. The total installed capacity of the Guthega, Murray 1 and Murray 2 Power Stations is 1,560,000 kilowatts.

The Snowy-Tumut Development provides for the diversion of the Eucumbene, the Upper Murrumbidgee and the Tooma Rivers to the Tumut River, and for the combined waters of these four rivers to generate electricity in four projects: Tumut 1, Tumut 2, Tumut 3 and Blowering, in their fall of 800 metres before release to the Tumut and thence to the Murrumbidgee. By agreement the Authority carried out the design and construction of Blowering Dam as an agent for the State of New South Wales, and the operation of Blowering Reservoir is the responsibility of the NSW Government.

The transmountain tunnel system includes the Eucumbene-Tumut Tunnel connecting Lake Eucumbene with Tumut Pond Reservoir. The normal function
of the tunnel is to divert water through the Great Dividing Range from Lake Eucumbene to the Tumut River but, during periods of high flow in the Tumut and Tooma Rivers, water in excess of that required for operating the power stations in the Tumut Valley is diverted in a reverse direction through the tunnel to Lake Eucumbene for storage. The total installed capacity in Tumut 1, 2 and 3 and Blowering Power Stations is 2,180,000 kilowatts, and this section of the Scheme provides some 1,380,000 megalitres of additional water annually to the Murrumbidgee River. [28]
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A HISTORY OF MOVEMENT TOWARDS A WATER-POWER SCHEME

Australia is a country of dramatic geographical changes ranging from tropical rainforests and rugged mountain ranges, to treeless plains and stony deserts. These varying conditions are accompanied and matched by the variations in climatic conditions. From the beginning of western recorded history in Australia the country has been beset by the somewhat cyclical fluctuations of drought and if not plenty, then at least sufficiency. In addition to droughts, high annual and seasonal rainfall variability have serious effects on dry land agriculture and pastoral output and hence the country's overall economy. Australia is the world's driest continent, and by world standards its water resources are relatively meagre.[1]

In the light of this it is not surprising that the Scheme was originally conceived of solely in terms of irrigation and as a defence against drought. This is particularly so when one considers that within two years of settlement of Sydney Cove the push outwards in search of suitable water supplies had already begun.

Exploration continued rapidly during this early period with droughts being the major motivator. The boundaries in which settlers were allowed to select land were redefined in 1829 bringing the sanctioned area to a southern limit just south of Canberra and eastward to the sea, but as Governor Gipps was to comment:

"... as well might it be attempted to confine the Arabs of the Desert within a circle, traced upon their sands, as to confine the graziers or woolgrowers of New South Wales within any bounds that can be properly
them: and as certainly as the Arabs would be starved, so also would the flocks and herds of New South Wales, if they were so confined, and the prosperity of the Country be at an end."(p.127)[2]

By 1845 it was estimated that there was a population of some 600 in the area between Cooma and the main Snowy range.

The relative frequency of droughts and their disastrous effects on primary production, the worst in 1895-1903 reduced Australian sheep numbers by more than 50%, cattle by 30% and average wheat yields to 2.4 bushels per acre, the lowest ever recorded[3], encouraged rural interests towards the end of the nineteenth century to look to the irrigation potential of the inland rivers.

Alfred Deakin, then a Minister of the Victorian Government, accompanied by an engineer, journeyed to America, Egypt, India and Italy, to observe irrigation practices and appraise their suitability for Victorian conditions. While in the United States, Deakin met two Canadian brothers, the Chaffeys, who had established successful irrigation developments in Canada and elsewhere, and invited them to investigate the possibilities of similar enterprises in Victoria. This invitation was accepted and the Chaffeys started work in 1887 at Renmark and Mildura on the River Murray. Although at first they met difficulties and misfortune the Chaffeys were able to prove beyond doubt the feasibility of successful irrigation agriculture in Australia.

A further significant event occurred in 1886 when the Victorian Government passed "The Irrigation Act" which profoundly influenced the whole
future of water development in Australia, by the conferring of public
ownership on all water supplies, and by authorising the construction of
Government works for water conservation and irrigation. Similar legisla-
tion followed subsequently in other States including New South Wales in
1896.

At about the same time the New South Wales Government set up
the Royal Commission on Water Conservation, under the Presidency of
W J Lyne MP (later Sir William Lyne). In 1884 P F Adams, Surveyor-General
of New South Wales, in evidence before the Royal Commission, suggested
that a diversion of the Snowy River to the Murrumbidgee for irrigation
purposes might be possible at a point about 8 kilometres above the Snowy's
junction with the Eucumbene. It was proposed that Snowy water would
flow by means of a canal across the lowest gap on the watershed divid-
ing the Snowy from the Murrumbidgee to Slack's Creek, a tributary of
the Murrumbidgee. This proposal meant, in effect, that an open channel
with no provision for a storage dam - would be excavated across the Great
Dividing Range at an elevation of about 914 metres.

As a result C Haylock, a New South Wales Government surveyor
in charge of parts of the Cooma District, was requested to review Adam's
proposal. Accordingly, Haylock commenced a survey about 17 km from
Cooma on the road to Jindabyne, but was forced to abandon it after 50
km on account of severe drought conditions. As no future opportunity
presented itself for Haylock to continue, the Royal Commission in the
following year deputed one of its members, J B Donkin, to determine the
practicability of the proposed diversion. The investigation subsequently
carried out by Donkin:

"... placed beyond the reason of doubt the question as to whether the levels of the intervening country would permit of a diversion from the Snowy into the Murrumbidgee, but there still remains the task of demonstrating absolutely by a detailed survey and levelling whether, in view of the physical difficulties to be overcome, the necessary works can be constructed at a cost which would afford a reasonable presumption that they would be remunerative."(p.725)[4]

Thus Donkin confirmed the physical practicability of Adams' earlier proposal, but left the question of its economic practicability unanswered. He foresaw however that:

"... great national necessities warrant correspondingly bold measures of relief. The levels and general configuration of the country from the Snowy River to Lake George demand instrumental examination, as they apparently point to an endowment from Nature for the express purpose of conducting water from an enormous snow-fed reservoir to the rich plains of the Monaro, and thence, after being stored in Lake George, to be distributed over thousands of square miles of arable land lying in the doab of the Lachlan and Murrumbidgee Rivers, now subject to long periods of disastrous droughts which render futile the labour of husbandry, cripple all mining industry, and surround with dread uncertainty every form of pastoral enterprise."(p.996) [5]

Although the Lyne Royal Commission on Water Conservation highlighted Adams' proposal to divert the Snowy River and confirmed the
viability of irrigation, no specific recommendations were made concerning the diversion of the Snowy River. There is no doubt that at the time this was a small issue compared with the paramount importance of the Murray and Murrumbidgee Rivers for irrigation. The question of the use of Snowy water for irrigation was however kept under review by the New South Wales Government as part of the work program of the newly created Water Conservation Service, a body established in terms of the New South Wales Water Act of 1896, as a branch of the Department of Mines and Agriculture (transferred later in the same year to the Department of Public Works). McKinney who as Principal Assistant Engineer for Water Conservation was responsible for the Service, also instituted a system of river gaugings and other studies of the Murrumbidgee and Murray. It is probably not too great a claim to say that the activities of the New South Wales Conservation Service helped to keep alive politically the question of the use of the waters of the Snowy particularly when public interest in the matters raised by the Lyne Royal Commission on Water Conservation was waning as a result of good seasons in the late 1880s and early 1890s.[6]

Not all investigators were enthusiastic about the prospects of successfully diverting the Snowy River for irrigation at an economical cost, and Adams' original proposal for the diversion of the Snowy (as investigated by Haylock and Donkin) was still a live issue with the New South Wales Government who brought it to the notice of the 1902 Interstate Royal Commission on the River Murray. This Commission obviously thought the proposal practical because it instructed its Secretary, R T McKay, who was then Assistant Engineer, Water Supply Branch, NSW Department of Public Works, to conduct a further investigation which was purported to have eventually
confirmed the view that Snowy water could be diverted across the Great Divide.

Notwithstanding confirmation of the physical practicability of diverting Snowy water inland, no action was taken by the New South Wales Government to implement Adams' irrigation proposal. As noted previously, interest in the whole idea waned as good seasons followed the drought years of the latter half of the century. The proposal did however highlight the need for irrigation at that time in parts of southeastern Australia, especially as a defence against drought, and identified the State of New South Wales as the prime mover in the initial schemes for the use of Snowy waters. The question of diversion for irrigation was not revived as a formal expression of public policy until World War II, and then as part of a dual-purpose proposal advanced by the New South Wales Water Conservation and Irrigation Commission.

The initial proposals for the use of Snowy waters for hydro-electric power, a process which simply refers to the method of generating electricity using pressurised water, were associated with the federation of the Australian states. The power potential of the Snowy River was first formally recognised by T Pridham an Assistant Engineer attached to the Royal Commission on Sites for the Seat of Government of the Commonwealth, who reported favourably on the Snowy as a source of power for Dalgety which at that stage was a preferred site. In his report Pridham found that the best site for a large hydro-electric installation was:

". . 22 miles from Dalgety, and suggested the construction of a tunnel about 3½ miles in length and a storage reservoir upstream. It was estimated that such a scheme would ensure a constant flow through
The tunnel of at least 1000 cubic feet per second which with a head of 300 feet, would furnish 20 000 net horsepower continuously."

(p.483)[7]

The power potential of the Snowy River was further confirmed by another government employee, the surveyor C R Scrivener, who was requested by the NSW Minister for Home Affairs, to obtain information on suitable sites in the southern Monaro for the proposed Federal capital. As a result of his investigation, Scrivener reported that:

". . with a suitable equalising weir the waters of the Snowy River might be utilised for the generation of electrical power",

but:

". . it would be wise, in estimating the capacity of the river, to adopt a minimum flow of 200 cubic feet per second, in order to meet a year or a succession of years of abnormally low rainfall. Now a flow of 200 cubic feet per second will give 17 horsepower for each foot of fall on the basis of 75 per cent efficiency; therefore, with a fall of 100 feet, 1 700 horsepower would be available. This fall, making due allowance for the necessity for placing the turbines above flood level, may be obtained between points on the Snowy River not more than one mile apart, in a direct line and within about five miles of the city site. With 1700 horsepower, water might be pumped from the river to the Service Reservoir, and the Federal City electrically lighted for many years."(p.504)[8]

Pridham and Scrivener's investigation established the feasibility of the Snowy as the source of power for the proposed national capital
and, when the present Canberra was finally selected in 1908 as the site, the limited availability of water power in the immediate locality was identified as being insufficient for future needs. (It should be noted that the capitals of Sydney and Melbourne were and are located within close proximity to coalfields which supply the fuel for their thermal stations.) Accordingly in 1909 the State of New South Wales agreed to allow the Commonwealth Government to use Snowy waters, without payment, for the provision of electric light and power for the then Federal Capital Territory.[9] The Commonwealth did not, at the time, exercise its powers in this regard, but the general principle of the use of Snowy waters for power was revived during World War I, as the New South Wales Public Works Department carried out surveys on the viability of using the waters in question for the generation of electricity for Sydney and the south eastern corner of the State.

The first firm proposals for the use of Snowy waters for power generation were made in 1920. Following preliminary surveys by the New South Wales Department of Public Works, W Corin, Chief Electrical Engineer, recommended the:

"... construction of a dam in the neighbourhood of Jindabyne, or possibly several dams on the contributing streams higher up. A race will lead thence to a subsidiary reservoir at Beloka Creek, the water being conveyed from this reservoir by a tunnel through the mountain and again by a short face to a pipe-head reservoir above Popongong Creek, a fall of some 1600 feet to the bed of the latter being obtained. The configuration of the country is such that to take full advantage of this fall it will be necessary to divide it into two sections, placing one
power station some 500 feet below the first pipe-head reservoir, and constructing a second power station when necessary to deal with the remaining 1000 feet fall or more. For the initial development no dams are necessary, the unregulated flow of the river being sufficient to develop approximately 24,000 kW continuously.\(^{(p.613)}\)[10]

The New South Wales Government took no action to implement this "Corin" or "Big Bend" scheme as it was known at that time and in 1937 a London firm of engineering consultants which had been commissioned by the New South Wales Government to investigate future dealing with the potential of the Snowy River for power generation recommended the construction of a dam at Jindabyne with a tunnel and pipeline to deliver water to power stations on the Snowy River at Biddi Point, a distance of 29 km, in order to generate 250,000 kilowatts.\(^{(11)}\)

This recommendation, essentially a power proposal with no provision for irrigation, had a mixed reception. In view of the limited advantages which would accrue to Victorian farmers through the use of Snowy waters for irrigation, Victoria was eager to see the development of the hydro-electric scheme as recommended by the consultants. On the other hand, New South Wales farmers in the southern part of the State regarded such a purely power proposal as a waste of valuable irrigation water, and accordingly, in February 1939, a meeting of water users at Griffith protested against the consultants' recommendation and formed the Murrumbidgee Valley Water Users' Association.

Whilst New South Wales and Victoria were divided on the optimum
use of Snowy waters, the recommendations posed the possibility of the Snowy providing some of the electrical needs of growing urban populations and secondary industries. In common with the earlier irrigation investigations, however, the hydro-electric scheme advocated by the consultants was regional rather than national in its concept.

The first formal proposals for the use of the Snowy for water supply purposes were associated with the projected needs of the Federal capital. In addition to recognising the power potential of the Snowy, both Pridham and Scrivener saw the possibility of the river supplying the proposed Federal capital site at Dalgety with its water requirements.[12]

These early proposals were extended in the 1920s to include a water supply for Sydney and intermediate country towns. In 1926 T W Keele - a member and former President of the Metropolitan Water Sewerage and Drainage Board - investigated the possibility of bringing Snowy water to Sydney from a storage dam at Jindabyne by tunnels and pipeline, following generally the railway line between Cooma and Sydney, and providing, also, for a water supply to Canberra and towns and settlements along the railway as far as Mittagong. Bound up with this proposal was a high-level scheme from Cataract Reservoir to deliver water on both sides of Sydney Harbour at sufficient pressure to eliminate the pumping of water.

The above proposal was reviewed in 1927 by J G S Purvis - Chief Engineer of the Metropolitan Water Sewerage and Drainage Board - but remained substantially unaltered with the exception of cost estimates. No action was taken by the Board to implement the Keele-Purvis proposals,
which were finally rejected in favour of the Warragamba scheme, primarily on the grounds of comparative costs. Interest in the use of the Snowy River for metropolitan water supply was revived during World War II on account of prolonged drought conditions in the Sydney water supply catchment area and resultant water restrictions. As before, the cost of diverting Snowy waters to supply Sydney was generally considered to be the limiting factor, and topical interest waned as conditions gradually improved.

The earliest recorded dual-purpose scheme was contained in Keele's original water supply proposal, which included the installation of generators at the outlet from the planned pressure pipelines near Sydney.[13]

Although Keele's 1926 scheme was the first dual purpose proposal, the idea of power generation and irrigation was not conceptually linked until 1937 when R F and C J Harnett proposed a series of power stations placed on the Murrumbidgee, into which the Snowy River had been diverted.

The general idea of the diversion of the Snowy River for more than one purpose (i.e. irrigation or power generation or water supply) was carried a stage further in 1940 by R T McKay, for many years a "... persistent advocate for utilising the waters of the Snowy River in a dual capacity, viz., to supplement the flow of the Murrumbidgee River and bring a supply to Sydney."(p.6)[14]

McKay's agitation for the formulation of a specific public policy for the development of the Snowy River was followed in 1941 by formal proposals from the New South Wales Water Conservation and Irrigation
Commission for the use of Snowy waters for both irrigation and hydro-electric power. The Commission proposed [15] to divert the Snowy River in order to augment the supply of water from Burrinjuck Reservoir for the purposes of meeting the increased demand for irrigation water in the Murrumbidgee Irrigation Area, and for further development of the area. The irrigation aspects of this proposal involved the diversion of 1,200 cubic feet per second from the Snowy to the Murrumbidgee by the construction of a dam on the Snowy at Jindabyne, diversion works between Jindabyne reservoir and the Murrumbidgee, and a dam on the Murrumbidgee at Billilngera. It was also recommended by the Commission that the construction be undertaken of auxiliary hydro-electric works with a total generating capacity of 50,000 kilowatts.

Interest in the development of an appropriate scheme, in whatever form, did not suddenly cease at this time, however because of its overall concern with the national economy the Commonwealth Government became a major party to the considerations of a resource capable of irrigation and power generation and which was likely to have impact beyond the borders of any one state.
References


5. Ibid.


12 Hardman, D.J. *op. cit.*

13 Keele, T.W. Report to the Metropolitan Water Sewerage and Drainage Board, recorded in *Report of the Snowy River Investigation Committee.*

14 *Report of the Snowy River Investigation Committee.*

THE ROLES OF THE THREE AUSTRALIAN GOVERNMENTS CONCERNED

It was obvious that for various and often conflicting reasons and priorities, the New South Wales, Victorian and Federal Governments all professed keen interest in the waters of the Snowy River.[1]

When the Australian Constitution was formulated at the turn of the century the problems of sufficient and regular water supply were obvious, and the electricity industry was in its infancy. The first electricity supply undertakings had been established during the late 1800s, primarily to supply electric lighting, and by 1900 the use of electricity for industrial power was still minimal. In factories in New South Wales for example, the horsepower of electric motors as a proportion of total horsepower of engines and motors was less than one percent.[2]

It should not be surprising therefore that there is no specific reference to electricity or water in the Australian constitution. The control of water rested with the States,[3] and the supply of electricity was in all probability seen as a public sector utility function which, in the Australian Federation, rests with the States.

Whilst neither of these subjects appear in the Australian constitution, it does not mean that there was no national interest in respect of them or no role for the Commonwealth. Any major industrial activity which demands a major share of the country's capital and which, by way of reliability, or unreliability, of supply affects the standard of living of every Australian, sooner or later, comes under scrutiny in terms of national interest and development.
The role of the Commonwealth Government in the establishment of the Snowy Mountains Authority and therefore of the Scheme can not be stressed too highly. That it was in by far the best position to raise the money for the construction of the Scheme can not be in doubt, but this must be placed in the context of the Commonwealth's initial concerns over the issues of post war reconstruction and development.

The issue of reconstruction went not just to the physical aspects of the community but also included the whole complex of social, economic and political arrangements. In short from a Government view it had to do with the whole aspirations of the community for a better way of life. The matters falling under that general heading however may have fallen within the competence of the Federal, State or Local Governments or semi Government bodies, and with that in mind a Federal Government Cabinet sub committee was established to review the progress of reconstruction planning and to co-ordinate and direct inter-departmental activities.[4] This sub committee comprised the Treasurer (Chifley), Attorney-General (Evatt), Minister for Social Security (Holloway), and Minister for Labour (Ward), and had the responsibility of examining schemes for reconstruction, planning, and correlation of all phases of reconstruction prior to making recommendations to Cabinet for the future conduct and direction of reconstruction. The conservation and reticulation of water was specifically identified as a most important feature of any reconstruction plan.[5]

Much debate followed the recommendation by the sub committee that the Commonwealth be invested with sufficiently wide powers to save the nation from the chaos likely to arise if it did not have such powers over national reconstruction. This was due in no small part to Member
of Parliament Menzies' assertions that such proposals were nothing but an excuse for a precipitate and premature election. Dr Evatt, the Attorney-General, replied on behalf of the Government that the assertions had no foundation in fact and that the proposals were a genuine attempt to guard against the anarchy and chaos that would threaten the country unless reconstruction was dealt with on a national level. In the event, the Constitution Alteration (War Aims and Reconstruction) Bill was introduced into Parliament by Dr Evatt on 1 October 1942, with the comment that the postwar problems of employment, housing, health, child welfare, vocational training, markets and price stability would require statescraft of a high order which supposedly could only be provided at a Commonwealth level.

The debate did not go ahead on the Bill but was referred to a special committee comprising eight members of the House of Representatives, four from the Senate, (of which half were from the Opposition), plus the Premier and Leader of the Opposition from each State Parliament, totalling twenty four. This committee reported to the only Constitutional Convention held since federation which unanimously decided that adequate powers should be granted to the Commonwealth for the resettlement of soldiers and advancement of their dependants and for the purposes of post war reconstruction. Bills were subsequently introduced into each State Parliament sponsored by the Leaders of the Government, irrespective of party, and were passed. On the 1 January 1943 the Minister for Post War Reconstruction (Chifley) announced the appointment of a Rural Reconstruction Commission comprised of politicians and academics whose charter it was to:
"...investigate problems associated with primary industry generally... to submit specific plans for the rehabilitation of rural industries, for such extension or rearrangement of primary industries as may be considered necessary, having regard to the markets available or likely to be available externally and internally in the post war period, and for the improvement of conditions of life in the rural areas." (p.35)[9]

Dr H C Coombs was appointed Director-General of Postwar Reconstruction on 15 January 1943.

Emphasis was placed on the planning for resettlement of servicemen and women, and the rehabilitation of primary production, based on potential markets available at home and abroad. The aim was to give farmers greater stability of income, and to improve efficiency in farming methods so that primary industry would become less dependent on subsidies. Secondary production capacity which had been greatly extended both in size and technique because of the requirements of war also needed to be maintained. An intensive national works program was seen to have been an important part of the Government's plans to satisfy both the primary and secondary sector needs. The principal matters under this program were said to be "...water conservation and the extension of electrical facilities." (p.47) [10] The further development of the supply and distribution of electric power in the post war years would greatly assist the range and possibilities of regional planning.

Acknowledging the role that the States had to play in developing and advising their more localised programs the Commonwealth established the National Works Council at the Premiers' Conference in July 1943.
This Council which consisted of representatives of the Commonwealth and the States with the Prime Minister as ex officio Chairman had as its aim the preparation of a national works program to provide for a smooth transition from war to peace time employment and development. The first stage of the plan was to provide a reservoir of work to provide immediate employment for service personnel returning to civilian life, thus inspiring confidence in the commercial and industrial sectors and maintaining the momentum of the nation's economy during the transitional period. The second and third stages of the plan involved the classification of works into priorities, and the concentration on studies effecting proposals for long range developmental plans.

Works projected for the first stage included the improvement of country water conservation and irrigation projects to overhaul the drought dangers and meet the demands of increased population, to improve the sanitation systems, and to develop power and light output because of the fact that many of the existing power supply systems had margins too small [11] to meet the anticipated needs.

The Commonwealth Government, based on the requests reaching it via the committee apparatus, and other information, decided that input from regional advisory bodies would greatly assist their considerations for regional development and industrial decentralisation. The views of these self interest groups would it was thought add another dimension to the planning process. It was through one of these groups, a deputation representing a great part of the Murrumbidgee Area, that the proposal for the diversion of the Snowy River waters for irrigation and generation of electrical power, first formally came to the attention of senior members
of the Council and of Government in May 1945. The deputation which met Messrs Chifley and Dedman (then Minister for Postwar Reconstruction) explained their proposal outlining that the cost would be in the order of £13 million. Neither Chifley nor Dedman appeared to place much merit on the proposal, with Dedman pointing out the essential involvement of the Victoria Government and the difficulty of formal agreements between the States, and Chifley suggesting that there were a great many things to do, with limited finance available.[12] In any event such a proposal required consultation amongst the States and the determination of problems and priorities.

Whilst the Commonwealth appeared to be paying little attention to these proposals, the New South Wales Government by contrast had been taking a most active interest with Victoria being interested but not as active. One of the many proposals which had been put forward for NSW consideration was for the use of the Snowy River (and which has been described in more detail in Chapter 2) was the dual-purpose power generation and irrigation proposal of R T McKay in 1940.[13] McKay's agitation for the formulation of a specific public policy for the development of the Snowy River was followed in 1941 by formal proposals from the New South Wales Water Conservation and Irrigation Commission for the use of Snowy waters for both irrigation and hydro-electric power. This continued interest led to the establishment by the NSW Government in 1942 of the Snowy River Investigation Committee under the chairmanship of the State Director of Public Works, J M Main, to investigate and report on proposals for the utilisation of the waters of the Snowy River.
The result of this investigation and study of the engineering proposals for the utilisation of the waters of the Snowy River produced a developmental report heavily biased on the side of New South Wales interests, especially for irrigation, at the expense of the Victoria Government's interests, especially in power generation. These findings were vigorously opposed by local interest groups in southeastern New South Wales and in Victoria who had been agitating for a hydro-electric scheme to promote the industrial development of the Monaro, Far South Coast and Gippsland.

The Victorian Government was not as protectionist in its consideration of the uses of the Snowy River though the State Electricity Commission of Victoria had surveyed the river and selected several possible sites for dams and power stations. The Victorian Government's position could best be summed up by the Chairman of the Victorian State Rivers and Water Supply Commission who suggested in 1941 that:

"... the development of the Snowy River Basin might be undertaken by a separate Authority comprising representatives of the Commonwealth and the two States concerned. A precedent for such action already exists in the River Murray Commission which has so satisfactorily handled the problems of the development and utilisation of the River Murray waters..." (p.98)[15]

It was about this time that the absence of appropriate multi-lateral agreements between the three interested governments became obvious.[16] The Commonwealth Government in addition to its general role as guardian of the national interest (including defense), had the legal right to use Snowy water for the provision of electric light and power for the Australian Capital
Territory. The diversion of the Snowy River waters for use in New South Wales, as recommended by the Snowy River Investigation Committee, would deprive Victoria of those waters and could well raise complex legal problems concerning state riparian rights. Indeed the Victorian Government was by no means an indifferent observer of New South Wales proposals, having considered over the years various proposals for the development of the Snowy in the interests of power generation, irrigation, flood control, and water supply for its own State needs.

Following the 1944 recommendations of the Snowy River Investigation Committee[17] which implied that the large scale use of Snowy waters was a national rather than Regional issue, the Premier of New South Wales (the Hon. W J McKell) wrote to Prime Minister Chifley on 5 September 1945 requesting the Commonwealth surrender its right to use Snowy River waters on the basis that New South Wales wanted it for irrigation purposes. At about the same time the Victorian Premier, Hon. J Cain, suggested as an alternative proposal that the diversion should be used to provide a considerable amount of electric power, whilst allowing the waters to still be available for irrigation purposes.

In the light of these conflicting views the Minister for Postwar Reconstruction, Mr Dedman, announced that a conference of Ministers representing the Commonwealth, New South Wales, and Victorian Governments was being planned to consider utilisation of the Snowy river waters. The Commonwealth's main concern was that:

"... in view of Australia's limited water resources the final decision the use of the River would ensure the maximum benefit for Australia
generally."(pp.21-22)[18]

The first conference took place on 25 and 26 June 1946 after a meeting of the Loan Council. As expected the New South Wales and Victorian Governments maintained their respective positions with regard to water utilisation and in the case of Victoria, power generation as well. The Commonwealth Government's position was that it had a moral obligation to ensure that legal (riperian) rights were maintained and that because the Commonwealth Department of Postwar Reconstruction had commenced a review of the potentialities of the various proposals for diversion of the Snowy, the States should take no further action at that time. As a result of this meeting it was agreed that the Commonwealth carry out a preliminary investigation over the ensuing six months in relation to the proposals of the two States,[19] irrigation in the Murrumbidgee as opposed to power generation and irrigation in the Murray.

The subsequent investigation was conducted along two separate but related lines of enquiry. One was directed to ascertain the practicability of building the requisite tunnels and storages and the costs involved, whilst the other was to assess the agricultural advantages inherent in the two schemes. In view of the fact that the hydro-electric power which would be available from either diversion was directly related to the type and design of the diversion works, issues relating to the quantity of power and its value were referred to a special engineering section of the inquiry which was led by the Director-General of the then Commonwealth Department of Works and Housing, Dr L F Loder, with the assistance of the water conservation, electricity and public works authorities of both New South
Wales and Victoria and the Commonwealth Army Survey Corps. This investigation concluded [20] that the proposal to divert the Snowy into the Murray was both practical and economical and that in view of the power potential of the Snowy and the urgent need for New South Wales and Victoria to plan for future power at an early date, that the matter be further investigated as soon as possible.

The agricultural and pastoral aspects were examined by an Economic Investigating Committee of six Commonwealth officers directed by the then Director-General of the Commonwealth Department of Post-War Reconstruction, Dr H C Coombs. This Committee with the assistance of the CSIRO's Division of Soils, sought information, advice and representations from all levels of State and Local Government and from individuals likely to be affected by either proposal. In trying to determine the relative merits of the two schemes, the sometimes conflicting criteria [21] examined included physical practicability, economy in the distribution of water, costs and returns, developments in production, and stabilisation of rural industry. The Committee finally concluded that from an agricultural point of view, diversion to the Murrumbidgee provided a better agricultural solution than did diversion to the Murray. An important qualification to this statement however was that whether greater benefits actually accrued depended on the policy on subsequent use as determined by the New South Wales Government. It was also pointed out by the Committee that should a decision be made in favour of the diversion to the Murray, effective use could still be made of these waters for irrigation purposes, though with less national advantage agriculturally.[22]
A joint report [23] based on these two investigations was subsequently prepared and established a prima facie case for the complete investigation of the proposal to divert the Snowy into the Murray, including the proposal to divert some or all of the water back from the Murray to the Murrumbidgee valley.

On 15 August 1947 the Federal Minister for Works (Lemmon) released the report [24] on the diversion of the Snowy River which commented that the exploitation of the full potentialities of Snowy River would not only overcome the shortages of power existing in New South Wales and Victoria but would ensure adequate supply for future industrial development, as well as extending the existing irrigation systems. This unique national asset [25] when developed to its full potential would provide irrigation for 300,000 acres with a gross annual return in the value of foodstuffs of at least £10,000,000 p.a., as well as some 750,000 horsepower. If the diversion went direct to the Murrumbidgee it would provide the same irrigation capacity but 500,000 horsepower less, which equated to 1,300,000 additional tons of coal to be used annually. Profit was expected to run at 8%, providing a higher yield than that shown by similar schemes run by utility companies overseas.[26]

As a result of these reports the second conference of Commonwealth and State Ministers decided to establish a committee under the Chairmanship of Dr L F Loder and consisting of two representatives from the Commonwealth and two each from New South Wales and Victoria with power to co-opt from the relevant Authorities, to make a complete detailed investigation, and to report to the Premiers' Conference by August 1948. This committee
(the Snowy River Committee) did report back [27] following a comprehensive survey of the resources of the Snowy River mountains area which included aerial and field surveys, test bores and further stream gaugings, and concluded that neither of the original proposals provided a satisfactory solution to the use of the waters from the whole area. Instead the Committee proposed that in addition to the Snowy River, the Upper Murrumbidgee, Tumut and Tooma Rivers be utilised to produce some 1 750 000 kilowatts. This was 60 000 kilowatts more than the consumption of Sydney and Melbourne combined at the time, and would save an estimated 4 600 000 tons of coal a year whilst still providing water for irrigation.[28]

The report was sent to the relevant States Premiers and Ministers in November 1948 and on 9 January 1949 Prime Minister Chifley announced [29] that even though the Report's recommendations were still being considered by the Governments, the proposals were of such magnitude and national interest that they should be made public. The speech, designed to fire the imagination of the population and inspire confidence in the post war economy emphasised the magnitude in increase in both power generation and water for irrigation, the saving of limited coal resources, decentralisation of industry away from the major population centres, and the safety of such a scheme from enemy attack. He described a scheme:

"... so vast and so beneficial is a national scheme in the fullest sense of the word. It would be one of the greatest projects in the history of Australia's development and I hope the Governments concerned will soon give consideration to it." (pp. 31-32) [30]
It should be remembered that during this time the Commonwealth Government was also assessing the viability of establishing other industries in country and remote areas. The Northern Australian Development Committee involved Commonwealth resources in the investigation of soils, pastures, and the geology of the northern regions of Australia. Other investigations included the Ord River Scheme, the Katherine Research Station and the pearling industry.

The Report of the Snowy River Committee was considered at the third conference of Ministers representing the Commonwealth, New South Wales and Victoria, held in Canberra on 14 February 1949. This conference approved the recommendations of the committee regarding the diversion of the flows of the Eucumbene and Tooma Rivers to the Tumut River with compensatory flow from the Snowy to the Murray River. In addition to this it directed the committee to further consider the utilisation of the balance of Snowy River waters and distribution of electric power between the States (once the requirements of the Commonwealth for defense and the ACT were met), and report back to the next Ministers' Conference on 30 June 1949.

It is interesting to note that the Commonwealth's intentions with regard to the development of the Scheme became clear when it was announced [31] on 12 May 1949 that Federal Cabinet had approved matters affecting the drafting of the Snowy Mountains Hydro-electric Power Bill, and further that the Bill was to be introduced during those sittings of the Parliament. The Scheme was again described as:

"... the greatest single project in our history. It is a plan for the whole
nation, belonging to no one State nor to any group or section. It is a two-sided plan, because it provides not only for the provision of vast supplies of new power but also for an immense decentralisation of industry and population. This is a plan for the nation, and it needs the nation to back it." (pp. 13-14)[32]

The Bill was introduced to the Commonwealth Parliament on 26 May 1949 by Minister for Works Lemmon, who said:

"The purpose of this bill is to set up the Snowy Mountains Hydro-electric Authority under the defense powers of the Commonwealth. Defense plans are divided into four categories - regional security, the defence forces, defence research, and finally the industrial capacity of the nation to support a defence machine. It is to the latter two aspects that this bill has its greatest application, for it proposes to harness a potential power of 1,720,000 kilowatts of hydro-electric power."(p.35)[33]

It was acknowledged in the speech to the Bill that final plans had not been decided on for the final third of the project but that the net result of the proposals would result in a power output roughly equivalent to the total production of all power stations operating in Australia at that time. Moreover the cost of power was about half that of conventionally produced power and given this and the supply of water it was not unrealistic to expect large inland cities to develop. Also contained in the speech was a reference [34] to the Authority giving consideration to the engagement of contractors from other parts of the world who had skilled teams capable of carrying out some of the construction work as well as its own day labour forces. The Bill was passed on 26 May 1949.
The second investigation \[35\] by the Snowy River Committee recommended that the balance of the Snowy River flow at Jindabyne be diverted to the Murray, that irrigation interests be safeguarded, that an agreement be reached between the three Governments regarding the apportionment of water, and that after deduction of the Commonwealth’s requirements power be shared between New South Wales and Victoria on the ratio of two thirds to one third. These recommendations were adopted at the fourth conference of Commonwealth and State Ministers in July 1949 where it was also agreed that the costs involved be met initially by Commonwealth funds, since it was the only body capable of financing such a scheme with repayment over a period of seventy years through the sale of electric power to the State Electricity Commissions. In essence the cost of irrigation was nil, as the cost of supplying irrigation water was to be met by increased tariffs for the supply of power.

As a result of the adoption of the recommendations an advisory committee was established to advise on the co-ordination of the Scheme with developments by the States for the use of the waters diverted and for the transmission, distribution, and use of the share of electric power made available to the States. This Committee did not actually operate until some years later (1953), and then only on an interim basis until the agreements were finalised and the Snowy Mountains Council came into being in 1959.

The path to resolution of the issues and agreement to construct the Scheme was not a smooth one. It was obvious that blocks of interest existed at all levels within the various Governments and in the particular regions. It was only through the mechanisms of the State that the momentum
and forces were channelled into a form which was capable of success on a national level.
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As previously mentioned the various governments closely associated with the Snowy Scheme had taken advantage of specialist advice gained from both overseas investigations and consultants coming to Australia. Young nations traditionally rely to an extent on their more technically and economically developed allies to assist in the provision of solutions to development problems. In addition to existing techniques and experience, cultural and political factors, geographical similarity which often gives rise to common economic problems and solutions, was a major factor in determining where Australia sought overseas assistance. This is exemplified by Deakin's 1884 investigations, when as Chairman of a Victorian Royal Commission, he investigated irrigation schemes and practices in India, Egypt, Italy and America. He was glowing in his reports about what he saw in America but far from enthusiastic about what he saw and learned in Europe.[1] The principal result of Deakin's visits were the Irrigation Act of 1886 which subsequently formed the basis of much of Australia's irrigation development, and the agreement between the Victorian Government and the Chaffey brothers for the establishment of an irrigation settlement at Mildura which proved beyond doubt the feasibility of successful irrigation agriculture in Australia. [2] Others too were impressed with developments in the United States. [3]

The history of water development in the U.S.A., particularly in the 17 Irrigation States, showed utilisation of the nation's water resources on behalf of its rapidly increasing population, with particular emphasis on power and irrigation benefits, integrated to give optimum national gain.

The first Reclamation Act, passed by Congress in 1902, authorised
the use of Federal funds received from the sale of public lands for the
survey, construction and maintenance of irrigation works, and provided
for payment of construction charges, without interest, by the beneficiaries
of a project. This Act also authorised the establishment of the Bureau of
Reclamation.

During the initial stages of reclamation the purpose was to provide
water for irrigation, little or no regard being paid to other benefits. However,
recognition of reclamation as a multi-purpose operation with hydro-electric
as well as irrigation benefits was marked by the construction of Roosevelt
Dam on the Salt River in Arizona, completed in 1911. Revenues from
the lease of power privileges for the sale of energy were directed to be
credited to the cost of the power plant and to other aspects of the project,
thus establishing a basic concept - the use of power revenues to pay the
overall project costs. [4]

Prior to the construction of Roosevelt Dam the Salt River Valley
was an arid wasteland, suitable at best and only in small parts for grazing.
Between 1910 and 1950 irrigation acreage increased from 15,000 to 300,000;
population from 24,000 to 330,000; farm revenues from $6 m. to $81 m;
and power revenue from $46,000 to over $8 m. Bank deposits increased
during the same period from $5 m. to $245 m.[5]

The Salt River Project was built by the Bureau of Reclamation on
behalf of the Salt River Valley Water Users Association. It should be
noted however that the operation of the project remained in the hands
of the Water Users' Association and not the Bureau of Reclamation as
an agency of the Federal Government. The first truly multi-purpose
development which was authorised by Congress to be built and operated by the Bureau of Reclamation was the Boulder Canyon Project. This work was constructed under the Boulder Canyon Project Act of 1928, and provided for the disposal of project produced hydro-electric power to repay the cost of project facilities allotted to the power purposes, and thereafter to repay the cost of irrigation, water storage and flood control.

In 1939 Reclamation Law was further adjusted to emphasise the importance of power and of municipal water supplies in determining project feasibility. A provision was included to the effect that those portions of the project cost allocated to the purposes of navigation and flood control were in the national interest and need not be repaid. Later legislation provided for the conservation of fish and wild-life resources on Reclamation projects and recognised such costs as non reimbursible. [6]

In 1944 Congress authorised the development of the Missouri River Basin in the States of Kansas, Nebraska, North and South Dakota, Montana and Wyoming (known in the 1930's as America's dust bowl), with the following priorities attaching to its water resources:

1. that flood control dams be built on the main stream, and tributaries and soil conservation measures be applied throughout the catchment area.

2. that hydro-electric plants be installed where feasible and practical to provide power for industries, municipalities and farm houses in the immediate areas; to intertie with transmission systems to the east and west; and thus provide revenue for repayment, with interest, of the hydro-electric facilities, and to assist in repayment of associated irrigation projects.
That irrigation projects be constructed, where water supply and storage facilities are adequate, for long-range agricultural stability.[7]

Whilst not without its early failures, U.S. achievements demonstrated according to Hudson [8] that well-planned multi purpose water resource development was, as a rule, sound financial policy, even though on the basis of the direct revenue, other than from the sale of power, such projects might appear totally uneconomic. An example of 15 reclamation projects constructed in the U.S.A. between 1916 and 1953, and collectively costing $269 m, showed that for the year 1953 individual income taxes paid by irrigation farmers and others whose employment directly stemmed from the developments amounted to $106 m. The estimated cumulative income tax revenues from the project areas since 1916 amounted to $800 m. [9] In addition, an estimate of the appropriate share of corporate and excise tax revenues collected in and directly attributable to the developments was $500 m. Thus, between 1916 and 1953, by making an investment of $269 m, the Federal Government collected, mainly from immediate beneficiaries, $1300 m, not counting direct payment of project costs by water and power users, i.e. taxes collected amounted to about five times the investment.

These developments and practices from America were closely monitored by a number of countries including Australia as a result of their engineering and subsequent related economic achievements.

As far as the Snowy Mountains Scheme was concerned, the first formal contact between the two countries came from a meeting between officers of the Department of External Affairs at the Australian Embassy
in Washington and officials of US State and Interior Departments on 29 March 1949. [10] At that meeting the 'Snowy River Diversion' project and benefits accruing from the expansion of irrigation systems and power development especially economic and defence aspects were outlined. The approach was "... accorded a most cordial welcome." [11] and the Australian representatives were confident that the U.S. administration would be able to assist with furnishing technical advice and services of Government experts under Public Law 402 (Smith - Mündt Act)[12], though this was by no means certain at that time.

The United States Information and Educational Exchange Act 1948 (or the Smith-Mundt Act - Public Law 402) had as its objectives: to enable the Government of the United States to promote a better understanding of the U.S. in other countries, and to increase mutual understanding between people of the U.S.A. and ... other countries. Among the means to be used in achieving these objectives were:

(i) An information service to disseminate abroad information about the United States of America.

(ii) An education exchange service to co-operate with other nations in:

(a) interchange of persons, knowledge and skills

(b) the rendering of technical and other services

(c) the interchange of developments in the field of education, the arts, the sciences.[13]

A note of caution was injected at that time when the Department of External Affairs advised the Australian Embassy that Australia would
not require U.S.A. to provide an overall service nor a comprehensive check on plans but rather it would appreciate advice on particular technical problems especially in connection with long tunnels of major dimensions through rock. The principal type of expert assistance required was said to be from construction engineers with experience in the use of modern plant for the construction of dams and tunnels and in the installation of machinery required for the development of hydro-electric power. [14] At the same time it was foreshadowed that after the legislation was passed in May, the head of the Authority would visit the U.S.A. and relevant U.S.B.R. experts would be invited to come to Australia for viewing the Scheme and to tender advice.

Contact was maintained with the U.S.A. Government and Department of Interior which included "a loan" [15] of Mr Dexheimer, Assistant Chief Construction Engineer of the U.S.B.R. for three months from November 1950 to look at tunnelling problems on site. This visit was arranged between Commissioner Hudson of the SMA and Dr S L Savage, a Consulting Engineer in Denver, and a past officer of the U.S.B.R. who acted on behalf of the Authority with the Bureau of Reclamation. [16] At the same time it was foreshadowed that SMA may require 2 or 3 specialist engineers on a loan basis to help the Chief Investigation Engineer on "intricate problems".[17]

Dr Savage suggested that the Australian Foreign Office should make a request to the U.S. State Department to obtain the services of Engineers [18], and whilst on a trip to Australia in October 1950 suggested that the Bureau of Reclamation would probably be prepared to employ approximately 3 "bright young engineers" [19] in their Denver office to gain experience in the Bureau of Reclamation's methods, a suggestion which was
enthusiastically received by Hudson.

On 20 March 1951 Hudson wrote to Minister for National Development Casey, suggesting that the Bureau of Reclamation could undertake certain design work for the Authority under the provisions of US Public Law 402. In the same letter Hudson stated that the best way the Bureau of Reclamation could assist would be to undertake the design of the Upper Tumut group of works from the upstream portal of the Adaminaby-Tumut tunnel to the tailrace of the second power station on the Upper Tumut River, including the Tooma-Tumut tunnel. The designs would be based on technical data furnished by the Authority and would be taken to the stage of compilation of specifications and contract drawings for letting the work by contract. He estimated, in a very approximate way, that the amount required for these services would be possibly $250,000.

This suggestion was further reinforced by reliance on the argument of national defence, the premier reason used in the Government arguments supporting construction of the Scheme. Hudson outlined that the construction program provided for completion of the Upper Tumut works excluding Tumut 2 within 8-9 years, thus providing an additional 250,000kW with T2 two years later adding another 250,000 kW. He argued that as an urgent defence measure the adoption of unorthodox methods including placing overseas contracts could mean the completion of all Upper Tumut works within 6 years. He further pointed out that power demand in combatant countries increased by approximately 50% during the early stages of World War 2 and that if war occurred within a few years, Australia could not meet demands for increased power unless steps were taken immediately to augment generating capacity over and above that planned by States.
Minister Casey accepted the argument and agreed that the use of the U.S.B.R. would enable the Snowy to go ahead much faster on the design side and make it unnecessary to employ high level design staff in high numbers. [25]

At a meeting of Cabinet sub-committee empowered to commit the Cabinet, comprising Messrs Fadden (Treasurer), Spender (External Affairs) and Casey (National Development) and Senator O'Sullivan (Trade & Customs), it was agreed to accept the opportunity to use U.S.B.R. staff, that arrangements would be made by Minister Casey through the appropriate diplomatic channels, and that the decision involved no prejudgement of the extent to which any of the Snowy works were to be proceeded. [26] (Such work was estimated to not exceed $250 000 or £112 000).

Discussions continued with the US Department of State and U.S.B.R, where it was finally agreed that Section 402 of Public Law 402 (Smith-Mundt Act) gave authority but that to get around Section 403 which held that the State could not enter into performance of services to a foreign government where such services may be performed adequately by qualified private American individuals and agencies, the project should be given a training slant in accordance with the basic objectives of Public Law 402, viz. information and educational exchange. [27]

The Australian reply [28] that the SMA would send up to 12 engineers for training and Commissioner or Associate Commissioner with full authority to enter into commitments were to travel to Denver, and that a senior Authority engineer would also go to the United States to act as Liaison Engineer, was unnecessary, however, as further discussions confirmed that
adequate statutory authority existed to enable the U.S.A. to undertake the service to the Scheme without the necessity to emphasise training.[29]

Following this, Associate Commissioner Lang proceeded to the U.S.A. on 27 May 1951. In the course of his negotiations with USBR he found that the defence significance of the Snowy Mountains development as a source of power for industry and irrigation water for food production was of considerable interest to the U.S. authorities.[19] It is not surprising therefore that the defence aspect was mentioned in the preamble to the Agreement (with the U.S.B.R.) in the same terms as used in the SMHE Power Act 1949. It is important to note that Lang also recognised and claimed that the services of the U.S.B.R. could be a decisive factor not only in expediting the early works for production of hydro-electric power and water for irrigation but also in developing an efficient organisation to carry out the balance of the works. [30]

In collaboration with the Australian Embassy, Lang conducted the negotiations and submitted a Draft Agreement and Report on the Agreement to the Australian Ambassador who subsequently wrote to the Prime Minister on 22 August expressing satisfaction with the Report and with the conclusions reached. [31]

Whilst the Draft Agreement was expressed in fairly general terms it was obvious that the final stages of the negotiations between the US Authorities and Mr Lang envisaged the adoption of a much more extensive and costly program than had been contemplated. Both the Agreement and the Report covered technical training and technical assistance and whilst the Technical Training section presented no real concerns to the Authority, the Technical Assistance section was not as clear cut. The
Report in dealing with technical assistance submitted three alternative schemes [32]:

Scheme A, in which the Bureau was to carry out all design and specification work which it can undertake including designs and specifications for power station equipment such as turbines, generators and transformers and appurtenant plant and equipment (estimated cost $3,886,000 or £1,750,000)

Scheme B, in which the Bureau was to carry out all design and specification work which it can undertake for civil engineering works leaving the Authority to carry out the design and specification work for power station equipment (estimated cost $2,086,000 or £939,000), and

Scheme C, the same as Scheme B except that the Bureau would proceed only to the stage where construction tenders are called (estimated cost $1,400,000 or £630,000)

The estimated costs, it should be remembered, were based on the fact that a unit of work in Australia costing £1 would cost $5 in America. This cost disparity, coupled with the fact that the Authority has been successful in recruiting some Norwegian Engineers who were experienced in the design and execution of deep pressure shafts, was sufficient for Hudson to recommend that a modified Scheme C be adopted as the Authority's preferred position. [34] The total estimated cost for both Technical Training and Assistance totalled $880,000.

This recommendation was subsequently contained and supported in Minister Spooner's letter to the Prime Minister Menzies. [35]
The Agreement was concluded by an exchange of notes between Ambassador Spender and Mr James E Webb, Acting Secretary of State and by the signature of an agreement concerning policies and procedures for the contemplated program by Mr T A Lang, Associate Commissioner, SMA, and Mr Goodrich W Lineweaver, Acting Commissioner of the Bureau of Reclamation. The Agreement provided that the Bureau of Reclamation would make available expert advice, services and training for Australian engineers who would not only study American projects and engineering practice but also co-operate with the Bureau in the production of designs and specifications for portion of the Snowy Mountains works. [36]
References

1 First Progress Report, Royal Commission on Water Supply, Victoria. 1883.


3 Ibid.


5 Ibid.


7 Ibid.

8 Ibid.


11 Ibid.


13 Ibid.

14 Department of External Affairs. Cablegram No.231 Australia to Australian Embassy in Washington. 10 April 1949, Folio 1D, G271(1).


16 Ibid.

17 Ibid.


19 Ibid.


22 Hudson, W. Teleprint to Casey, R. No. 8146 27 March 1951. Folio 13, G271(1).

23 Prime Minister Chifley, Address to the Nation. 9 Jan. 1949. Digest of Decisions and Announcements No.141.


26 Cabinet Sub Committee Decision No.131. Sydney 30 March 1951. Folio 16, G271(1).


28 Hudson, W. Cablegram to Department of External Affairs Washington Embassy. 25 April 1951. Folio 28, G271(1)

29 Department of External Affairs Memorandum to Hudson, W. 7 May 1951. Folio 36, G271(1).


31 Ibid, and Ambassador Spender's letter to Prime Minister Menzies 22 August 1951. Folio 46, G271(1).

32 Hudson, W. Memorandum to the Minister for National Development Spooner 21 September 1951. Folio 69, G271(1).

33 Ibid.

34 Ibid.


The agreement that the USBR would make available expert assistance primarily took the form of design and specification assistance for that portion of the Scheme known as the Upper Tumut works, the completion of which was as important for the yielding of early results as it was for the laying of foundations for water control to allow the Lower Tumut sections of the Scheme to be built later.

The fact that the USBR was requested to undertake a modified "Scheme C", all civil engineering design and specification work to the stage where construction tenders were called, recognised that, notwithstanding the nationalistic arguments of Wootten[1] that there were sufficient qualified engineers in Australia and to not use them was to demonstrate a sense of inferiority, there simply were insufficient numbers of trained and skilled personnel available to the Authority at that time. This lack of resources was not capable of being redressed within the timeframes set for the project's completion by the Government, either by the importation of suitably skilled people or the training of existing staff. Each of these issues, use of Australian engineers, immigration and training were addressed within the life of the project and each contributed significantly to the successful completion of the total Scheme. The limiting of the USBR to this role also meant that as more Authority engineers reached the standard of efficiency required and experience gained, they could progressively take over the work for other Scheme projects, building on the foundations laid by virtue of the technical assistance provided by the USBR.
In addition to the resources question it was clear that the USBR possessed and held in Denver the technology that was required for the construction of the Scheme. This was stored in its people, its documentation, and its work methods and practices. The USBR had the experience, expertise and the capacity to assist.

By the early 1950s the USBR had achieved a significant reputation worldwide for its engineering achievements, including engineering design and supervision of construction, particularly involving structures of large size and complexity. These achievements included bridges, canals and open channel systems, dams, communications, earth structures, foundations, flood control, pipelines, highways, power generation transmission and distribution, surveying and mapping, tunnels and water systems. In the fifty year history up to 1950 its engineering achievements included the Hoover Dam (highest dam), Grand Coulee Dam (largest concrete dam), Shasta Dam (second highest dam), Anderson Ranch Dam (highest earthfill dam), Friant-Kern Canal (longest irrigation canal), Grand Coulee Feeder Canal (largest irrigation canal), All-American Canal System (longest integrated canal system in operation), Alva B. Adams Tunnel (longest irrigation tunnel), Grand Coulee Power Plant (largest hydro-electric power plant), and Grand Coulee Pumping Plant (largest pumping plant).[2]

As a result of its reputation in the field of design and construction of structures of unprecedented size and complexity, the Bureau of Reclamation had during the period to 1950 assisted private engineering firms, state and local government agencies, and the departments of Government in their engineering undertakings. In general this technical assistance consisted
of consulting services on basic designs, preparation of designs and specifications for structures, and laboratory research. Some examples of this work included studies, planning, preparation of designs, specifications and construction drawings, and technical assistance for construction of Falcon Dam, a 13,000,000 cubic yard earthfill structure on the Rio Grande between the United States and Mexico, for the International Boundary and Water Commission; tests of samples of Barite aggregate for concrete, and tests of drill samples at Eniwetok Proving Grounds for the Atomic Energy Commission; hydraulic model tests for flood protective works at Morrison, Colorado for the US Department of the Army; basic research in the development of lightweight concrete for the Housing and Home Finance Agency; design of Madden Dam and Power Plant for the Panama canal; and design of Norris and Wheeler Dams and Power Plants for the Tennessee Valley Authority.[3]

In addition to these projects the USBR provided assistance to foreign countries in various fields of water resource use and developments including irrigation, hydro electric power, drainage and comprehensive basin developments. These included preparation of designs and estimates for Yangtze Dam, power plant and navigation facilities, Yangtze River Basin for the Republic of China; trial load and stability analysis of the proposed 780 foot high concrete Kosi Dam for the Central Water Power, Irrigation and Navigation Commission, Government of India; testing of Australian-made cement in connection with construction of the Warragamba Dam for the Metropolitan Water, Sewerage and Drainage Board of New South Wales; and embankment material tests for Hirakud Dam, India, and Gal Oya Dam, Ceylon, for the International Engineering Company.[4]
On the 1 February 1931, there were at the Reclamation Engineering Centre 780 engineers in the following specialities: Civil, mechanical, electrical, electronics, materials, safety, structural, hydraulic, construction, chemical, production and programs, architectural, and general. Other specialists included chemists and petrographers, geologists, hydrometeorologists, inspectors, physicists, geophysicists, architects and technical illustrators.

Engineering expertise is usually not only a product of experience but also of the availability of facilities where research and development can be undertaken. In this latter respect the Reclamation Engineering Centre in Denver facilitated the resolution of many complex design problems by the Bureau engineers and designers. One example of this equipment was the A-C network analyzer used by the electrical engineers to study in miniature the planning, design and operating problems of complex power systems. The characteristics of the electric power system to be studied were simulated by appropriate values of resistance, reactance, and capacitance on the units making up the analyzer. In a complex electrical network many quantities are difficult if not impossible to determine by mathematical calculations. The network analyzer reduced the unknowns and allowed engineers to determine much more closely the actual needs of the proposed power system. In the design of new power systems, which was one of the many uses of the analyzer, the Bureau had accomplished savings of many hundreds of thousands of dollars by the elimination of transmission line sections and closer design of other equipment over that which would have been thought necessary with ordinary planning methods.[5]

Another facility used directly in design was the photoelastic laboratory where the most modern photoelastic and analogy apparatus of that time
was available for use in solving a wide variety of design problems. Photoelastic and analogy methods are very useful when analytical solutions to design problems are too time-consuming or are extremely difficult. Equipment available included the photoelastic polariscope, Babinet compensator, and photoelastic interferometer for studies of stresses in two-dimensional structural models; the scatter polariscope and electric ovens for studying stresses in three-dimensional models; the Beggs deformeter for studying statically indeterminate structures of the frame type; and the electric analogy tray and membrane analogy for studying a wide variety of problems involving steady-state potential flow and hydrodynamic effects of earthquakes amongst other things. Also available was an earthquake analyzer for subjecting a structure (represented by a torsional pendulum with similar elasticity characteristics) to known recorded earthquakes. A reflex integraph was available for solving complicated differential equations accurately and rapidly.[6]

In engineering choice [7] there evolves a norm or range of best practices that serves as a guide to the replication of technology under similar circumstances. It was these practices and techniques that the Authority looked for assistance in planning and constructing the Upper Tumut section of the Scheme.

The minimum program for technical assistance services was initially to comprise design and specification work to a stage where contract bids could be called for the Adaminaby-Tumut Pond Tunnel (including access adits and shafts, portals and control works), Tumut Pond Dam, and the tunnel from Tumut Pond to the surge tank (including intake portal, surge tank and access adit).
In accordance with the provisions of Section 4 of the Agreement, the Authority forwarded preliminary information regarding field data and results of investigations relating to the projects the Bureau was to carry out. These included extracts from the surveying and plan catalogue relating to the Upper Tumut River and Adaminaby areas, contour plans of the dam site and saddles adjacent to the dam site, river cross sections, tunnel portal site survey, Tumut Pond dam site surveys, T1 site and Tumut River downstream survey, T1 Power Station contour plan, Tumut Pond Catchment contour, contour plan T1 and Tumut River Downstream, Adaminaby Storage Area contour plan, topographic maps of the Kiandra and Snowy Plains areas, and Tumut Pond and T1 triangulation diagram. These were complemented by aerial photographs of the Tumut Valley below Tumut Pond, upstream of Tumut Pond to Power Station T1 site, and the tunnel line Adaminaby to Tumut Pond. Reports included a summary of the Adaminaby-T1 Project investigations including a general description of the Scheme, a discussion of the suggested construction layout for the Adaminaby-Tumut Pond Tunnel, preliminary report of the geological investigations for the T1 Project, estimates of flood flow and general hydrological information, climatological information, a survey of sources of sand and concrete aggregate within the Adaminaby-T1 area, and importantly approximate unit rates for estimating as at November 1951. Capacity curves for both the Adaminaby Dam and Tumut Pond were also sent. [8]

This information was reviewed by the Chief Engineer of the Bureau and his staff who indicated that although the information supplied was a general indication of conditions for the works under consideration, it was inadequate as a basis for the accurate preparation of designs and specifications suitable for contract bids. It was thus considered desirable for
selected Bureau personnel to proceed to Australia at an early date in order to confer with the Authority on the work to be carried out by the Bureau and to assist in the planning and compilation of investigation data and the carrying out of investigations for this work. Bureau representatives, it was suggested, should include officers skilled in construction material investigation and engineering geology, dam investigations and design, and tunnel investigation and designs. The most convenient arrangement was for the Bureau to send a senior officer of wide experience able to co-ordinate and control the activities of other officers specially skilled in the above areas. Those selected to visit Australia were Messrs W A Dexheimer and A B Reeves, both having had wide experience on tunnels, whilst Messrs J J Hammond and R Rhoades were the Bureau's Senior Engineers in concrete dams and geology respectively. [9] All arrived in Australia during February 1952. Their visit was greatly appreciated and undoubtedly helped the Authority in formulating its immediate program of works, "and getting things under way expeditiously". [10]

In addition to these engineers, Dr J L Savage who assisted in the original discussions and negotiations between the SMA and USBR, and Mr F C Walker the senior engineer of the earth dam section of the Bureau, who were both in Australia at that time, took part in site inspections and discussions regarding the Tumut Pond Dam site, from the 16 to 23 February 1952.

The preliminary design layouts prepared by the Bureau based on information supplied by the Authority were brought to Australia by Dexheimer. He also brought with him estimates for alternative layouts in relation
to Tumut Pond Dam, which were based on similarly situated jobs in the USA, and schedules of quantities for the various layouts so that unit rates could be inserted by the Authority and estimates prepared for Australian conditions.

At this time the Authority was advised that it was necessary to prepare a report setting out the operational studies in relation to T1 Power Station. Several typical reports prepared by the Bureau for similar work were sent to the Authority to be used as a 'reference' during the preparation of the Authority's report. [11] The work to be designed by the Bureau was to be based on this operational report.

From the commencement of training and technical assistance by the Bureau to December 31, 1952, cost was $315,450, made up as follows:

Overhead charge (in accordance with the Agreement) $ 500
Adaminaby Tunnel - preparation of designs and eng.spec's 80 000
Tumut-T1 Tunnel - " " " " 30 000
Tumut Pond Dam - " " " " 90 000
Preliminary work leading up to preparation of final designs and specifications 100 000
2 trainees for 6 months arrived 26.11.51 685
2 " " 12 months " " 1 370
4 " " " " to arrive January 1952 2 735
4 " " 11 " to arrive February 1952 2 510
Assignment of 4 Bureau Engineers to Australia for 60 days 7 650

Grand Total: $315 450
In all cases the specifications were patterned after Bureau specifications [12] with no attempt to modify them for any Australian conditions. This arrangement proved quite satisfactory to the Authority. [13]

The first of the designs and contract plans for work on the Upper Tumut River were received in January 1953. In his letter [14] conveying the Authority's deep appreciation of the help the Bureau was giving both in the preparation of designs and in the training and experience Authority engineers were receiving, Hudson foreshadowed that the Bureau might consider the execution of additional design work, and the secondment of two engineers with extensive experience in the construction of large dams, tunnels and associated works, and in the supervision and administration of large contracts.

Hudson further wrote to the USBR on 1 June 1953 [15] following up discussions between Lang (SMA) and Dexheimer and Reeves during their visit to the Snowy Mountains area in March 1953, and his letter of 19 January 1953, advising that it was proposed to ask the Bureau to carry out detailed designs and drawings in connection with those works of the Upper Tumut developments for which it had already prepared specification designs and contract drawings. These works were the Eucumbene-Tumut Tunnel, the Tumut Pond Dam and T1 Pressure Tunnel and Surge Tank. In addition, it was hoped that the Bureau would have been able to undertake further work in connection with the T2 Project which was immediately downstream of the T1 development on the Tumut River, and it was probable that there would be other projects, such as the Kosciusko Dam, that the Authority would seek Bureau assistance with. This was additional to the review of the designs of Adaminaby Dam and the actual designs and specifications for the permanent outlet gates of that dam being constructed
by the NSW Public Works Department on behalf of the Authority which it had earlier requested the Bureau to do. He requested the Bureau to also prepare detailed Design Reports, Designer's Operating Instructions and Performance Specifications for the gates, valves and other mechanical installations for the work which the Bureau has already designed for the Authority. [16]

It had become obvious that the Bureau was playing a significant role in the design stages and this in turn was allowing the Scheme to rapidly develop. With the view that such assistance should continue, Hudson advised that the immediate program of works, additional to that already authorised, that the Authority would want the Bureau to carry out was at least equivalent to that which had already been carried out on its behalf. Similarly, the SMA was anxious to continue the in-service training scheme.

Hudson still held the view that the Authority was weak in certain areas and pressed the Bureau to second several engineers with extensive experience in the construction of large dams, tunnels, power stations and associated works to strengthen the Authority's staff engaged on the supervision and administration of large contracts. This would embrace a very senior engineer who would be capable of co-ordinating the Authority's construction and design work, keeping in mind the major contracts which were to be awarded towards the end of 1953, as well as several other engineers who could assist on major sections of the work or act as project engineers for the major contracts.

Hudson saw the continuance of technical assistance by the Bureau as a vital factor in enabling the Authority:
"...to implement the very large program of work, which it is carrying out for the Australian Government in the immediate future. This assistance will also enable the Authority to consolidate its organisation so as to cope with the very much greater volume of work required to bring the Snowy Mountains Scheme to completion". (p.2) [17]

Lineweaver replied that the Bureau could see no reason why they would or should not be able to take care of the work and other activities outlined by Hudson. [18]

Hudson followed up the issue of seconded engineers with an alternative proposal to that already mentioned. [19] This alternative was for a senior engineer to undertake the overall direction and administration of all construction work, i.e. both major contracts and work being done by the Authority forces; a senior engineer to take charge of design and the scientific services group (research); and up to 3 engineers who would work under the senior engineer acting as project engineers for the main contracts. It was at this time that Mr W A Dexheimer, who had visited the Scheme on several occasions to provide advice and a liaison service, was appointed Commissioner of the USBR. The Authority was thus in the fortunate position of having in the senior officer of the Bureau someone who had first hand experience of the Scheme's design, its location and geography and its resources.

On 23 October 1953 the USBR confirmed that it would assist the Authority in performing designwork for the T2 Project (as discussed during Hudson's visit to Washington and Denver) in accordance with recent correspondence to Lineweaver and McClellan. Work on the general layout of the project would commence as soon as the basic information and re-
commendations were received. The Bureau also confirmed the assignment of senior engineering personnel to serve with the Authority:

"... to assist in its program of construction of large dams, tunnels, power stations and associated works and its supervision and administration of the associated contracts". (p.1) [20]

These advisors arrived in Australia during 1953.

Following discussions between the Authority and the water conservation authorities of NSW and Victoria towards the end of 1953 it became apparent that the Authority was able to divert water from the Tooma to the Tumut River at a much earlier date than was originally planned. This necessitated certain changes to the Authority's design and construction programs, which were to be discussed in detail in Australia with Mr H Bahmeier, the Bureau's Senior Engineering Advisor and his associates, before finalising the forward program and defining the work to be carried out by the Bureau. It was not anticipated that this would cause any change in the overall magnitude of the work, and a further $140 000 had been sent to the U.S. State Department to cover the immediate needs of the Bureau [21] in accordance with the agreed financial arrangements.

Following detailed investigations and discussions regarding the T2 project which consisted of a diversion dam, a headrace tunnel with intake structure, headrace tunnel surge chamber, twin pressure shafts and power station, tailrace tunnel, surge chamber and tailrace tunnel, it was decided by the Authority that the work should be split, the Authority's forces designing the pressure shafts, the power station, and the spillway gates on the diversion dam, and the Bureau providing a general review of the proposed layout
of the project; the preparation of the designs and contract and construction drawings for all civil engineering works associated with T2 Diversion dam, intake and headrace tunnel, Headrace Tunnel Surge Chamber, Tailrace Tunnel Surge Chamber and Tailrace Tunnel; preparation of designs and drawings for all structures associated with the above works, with the exception of the spillway gates on the Diversion Dam; and the preparation of draft clauses for the technical specifications relating to works designed. To assist with the portion of the Bureau's assignment, the Authority sent them the Report on Investigations into the T2 Project, Regional and Project geology reports, alternative site proposal, status of geological investigations as at 21 March 1955, analysis of water in the Tumut River, concrete aggregates, hydrological data, rating curves, drafting standards, photo-theodolite photographs, and survey plans and negatives. The Bureau advised its preparedness to assist with the work with a preliminary cost estimate of $375 000 [23].

Following a review of its program for the years 1955-57 the Authority came to the conclusion [23] that it would be most advantageous to bring the diversion of the Tooma River to the Tumut River forward so that completion of the diversion virtually coincided with the completion of the T1 Power Station towards the end of 1959. This project consisted essentially of a dam on the Tooma River and a diversion tunnel to the Tumut River at Tumut Pond. Originally, it was anticipated that this might connect into the Eucumbene-Tumut Tunnel near Tumut Pond but later studies showed that it was desirable to have a separate entrance to Tumut Pond with a cross connection to the Eucumbene-Tumut Tunnel with appropriate regulating valves and control gates. It was proposed that the work could be divided, by the Bureau undertaking the lower part of the tunnel, and also the design and arrangement of the outlet to Tumut Pond and the
interconnections with the Eucumbene-Tumut Tunnel. This would involve at least two control structures as well as the tunnel design. Bureau officers were familiar with the general layout of Tumut Pond and the lower end of the Eucumbene-Tumut Tunnel, the design of which was carried out by the Bureau.

The Bureau advised the Authority that in light of its heavy program, there would be a limitation on the work they could perform. They were able to assist with the complete design and detailing of the gates or valves, and operating equipment, with transmittal of completed tracings, together with calculations, manufacturer's data on standard accessories, and drafts of specifications. These would be completed in the same manner and to the same extent as for earlier projects however, if applicable existing Bureau gate and hoist designs would be modified to suit in the same manner as modifications to existing designs for spillway radial gates and hoists did for outlet guard and regulating gates and hoists at T2 Diversion Dam were contemplated. They also prepared general informational data including schematic diagrams of electrical wiring and hydraulic piping.[24] Local control equipment for activating this was also designed and detailed, and information relative to the telemetering and remote control equipment was also developed.

The USBR proceeded to assist with T2 Project however this was not without some problems. After completion of the reinforcement drawings and bar lists for the tunnels and tunnel structures on the Eucumbene-Tumut and T1 Projects, the Bureau became concerned with the time and personnel estimated to be required on similar work on the T2 Project tunnels and tunnel structures. Its inability to engage qualified engineering personnel
together with their increased domestic work program forced the Bureau to examine all available alternatives regarding staff and workload. They requested the Authority to assign six of their engineering trainees to Denver for 8 to 10 weeks beginning approximately March 1957, to assist with the preparation of reinforcement drawings for T2 Project. [25] This was regarded as an excellent opportunity for them to gain experience in that type of work and to become familiar with detail designs. In regard to the Tooma-Tumut diversion, designs were completed by October 1956 and all reinforcement drawings and bar lists for concrete work were completed by April 1957. Designs on the T2 Project were actioned on the basis that specification drawings were completed in November 1956 and final design drawings by March 1957.

As design assistance on the Tumut 1 project was completed the Bureau took on additional work from the Tumut 2 and other Snowy projects though this was clearly more than had been envisaged in the initial approval for assistance by the USBR. This additional work included all drawings and technical paragraphs to enable contracts to be called, design drawings for the four adits (specifying location, size, grade and other details) and terminus of the tunnel for the Adaminaby-Snowy Tunnel, at a cost of $165,000, and complete stress analysis and preparation of all specification drawings and technical paragraphs for the Island Bend Dam, at a cost of $80,500. This work was completed by the end of June 1958 [26].

Other technical assistance provided by the USBR was based on specific requests from the Authority which flowed from both sequential development in planning of the Scheme, and from changes made to the design criteria as a result of further investigations by Authority and USBR staff. The former category included design work for the Murrumbidgee-Eucumbene
Diversion, and the Snowy-Geehi Project [27], a nine mile nominally unlined tunnel with associated connections, shafts, gates, outlet structures and adits, whilst the latter included modifications to construction drawings for the Tumut 2 Diversion Dam and associated head and tailrace surge tank structures, and outlet gates.

The design layouts both preliminary and final, schedules of quantities for the various layouts, the use by the Authority of the 'typical reports' as used by the Bureau, the use of the USBR model for specifications, completion of detailed designs and drawings (as opposed to specification designs and contract drawings), design reports, operating instructions, performance specifications, construction drawings, completed tracings, calculations and manufacturers data on standard accessories, modifications of existing designs to suit, schematic diagrams for electrical wiring and hydraulic piping, design and detail of control equipment, and development of relevant information on telemetering and remote control equipment, were all examples of a technical ability possessed by the Bureau in the USA, a source clearly external to the area in which the technology was to be applied. This direct assistance by the USBR enabled the transfer of the technology to the Scheme and to Australia. Without this process which was mainly confined to formal, non interactive methods but also involved some personal contact, the construction of the Upper Tumut works would not have been able to continue at the pace, both in terms of construction and sequence, that it did. It is also a fact that construction and operation of the other parts of the Scheme would not have been completed as they were without the application by Scheme officers of principles, methods and techniques learned from Bureau practices and procedures, and directly from USBR personnel. The
Authority incorporated in its practices, the superior elements of Bureau practice.
References

1 Wootten, S. E. (Gen. Secretary of Association of Architects, Engineers, Surveyors & Draftsmen of Australia) Letter to Prime Minister Chifley 16 May 1949. Folio 2, G.271(1).


3 Ibid.

4 Ibid.

5 Ibid.

6 Ibid.


11 Pinkerton I.L. Memorandum to Hudson, W. 7 February 1952. Folio 120, G.271(1).

12 U.S. Department of State, Washington, Note to Australian Embassy, Washington setting out costs and conditions attaching to the USBR-SMA Agreement. 5 February 1952. Folio 1, G.294(1).


16 Ibid.

17 Ibid.


27 Snowy Mountains Authority Meeting No.198. 24 March 1959. Folio 311, G.271(2).

File G 271(1) op. cit.


File G 271(2) SMA file - Agreement Between the Commonwealth of Australia and the United States of America for Technical Training and Technical Assistance - Policy. (Part 2)
When the Snowy Mountains Authority was established in 1949, planning had been developed only to the stage of establishing the general policy of water utilisation and of ensuring that the general proposal was practically and economically sound.

The Authority thus had the task of preparing a strategy to achieve the proper and economical construction of the Scheme which included detailed land, geological and hydrographical surveys to ascertain the basic data as to topography, foundation conditions and water resources, and the planning of the most economical full utilisation of the water resources of the area. The order and rate of construction had also to be planned to ensure the early development of power to relieve existing shortages, the most economical operation of the hydro stations in conjunction with existing thermal stations, that power would be produced in stages suitable for absorption by the existing power systems of New South Wales and Victoria, and the early inland diversion of Snowy waters to increase irrigation supplies.

Inherent in this strategy was planning for and of the economical sizes and types of structures such as sizes of tunnels, heights and types of dams, capacities of racelines, transmission voltages; the location and nature of access roads and of location and layout of townships, workshops and other buildings for construction purposes; and the most economic construction methods and procedures for construction plant, equipment and the provision of power for construction purposes.

The Scheme is a complex one both in regard to the types of engineering structures involved and in the nature of the river diversions.
Particular features of the Scheme include the large amount of tunnelling required, the underground location of many of the power stations and the use of very high voltage transmission lines to convey the energy produced to the load centres in NSW and Victoria. It should be noted here that this 330 000 volt transmission which formed an important link between the power distribution centres of the states of Victoria and New South Wales was the first of its kind in the southern hemisphere.

As early as April 1949 it was foreshadowed that the Snowy River Construction Authority as it was then known, would invite United States experts whose knowledge covered the problem areas likely to arise on the Scheme, to come to Australia, look over the project and tender advice. These problem areas were thought to cover the construction of dams, long tunnels of major dimension through rock, and the installation of machinery required for the development of hydro-electric power. Indeed formal arrangements had engineers of the USBR visiting the Scheme to assist with initial design considerations. These engineers included Assistant Chief Construction Engineer, later Commissioner, of the USBR, Mr W Dexheimer, in November 1950, who returned in 1952 with Mr A E Reeves in connection with the initiation of the first phase of the co-operative program between the USBR and the SMA. Both of these engineers had been in close contact with the work as it had developed since 1950.

The first USBR Advisers arrived in Cooma early in 1954. The team included Messrs H F Bahmeier as Senior Engineering Adviser, H R Orr as Engineering Design Adviser, E C Higginson as Engineering Adviser, and R B Ward and J R Walton as Construction Engineering Advisers, all of whom had a close knowledge of the technologies to be introduced.
Following Associate Commissioner and Chief Engineer McClellan's visit to Australia in June 1954, Commissioner Hudson [6] advised of the awarding of the three major contracts for the UT Development works and as a direct result of the visit, the re-organisation of some of the Authority's work areas including the placement of the overall control and co-ordination of the Major Contracts Division, Design Division and Scientific Services Division under Mr I B Hughes as Chief Civil Engineer. The Bureau's Senior Engineering Adviser, Mr H F Bahmeier, was assigned the role of advising and assisting the Chief Civil Engineer in regard to the overall control of these three Divisions with particular attention to the needs and services not only of these Divisions, but also for the Upper Tumut Development contracts.

Mr Orr, Engineering Design Adviser, was attached to the Design Division, and Mr Higginson as Engineer Adviser to the Scientific Services Division. Messrs Ward and Walton, Construction Engineering Advisers, were attached to the Major Contracts Division and were stationed at Cabramurra to advise and assist the Senior Resident Engineer who was in charge of the field supervision of the contracts.

It was originally proposed that there should have been a third construction Engineering Adviser but it was finally decided that Messrs Ward and Walton could satisfactorily carry out the necessary field supervision work. At that time it was anticipated that the contractors would establish their main offices in the field, probably in the vicinity of Cabramurra. Kaiser-Walsh-Perini-Raymond who were awarded the contracts for the Eucumbene-Tumut tunnel and the Tumut Pond Dam, established their main office at Cooma with field offices at Eucumbene Portal, Junction Shaft and Cabramurra,
however, whilst the French group had their main office in the field near Cabramurra. This undoubtedly complicated effective communications, field supervision and contract administration. In light of this and the lack of experience of the Authority's engineers in handling contracts of the magnitude of those for the T.1 works, it became more obvious to Hudson, as the detailed organisation for the administration of the contracts developed, that there was a pressing need for a contract administration engineer to assist the Major Contracts Division at Cooma and to expedite the engineering work required to properly service the contracts.[7] The resignation of one of the Authority's senior engineers experienced in tunnel construction and who had been allocated to the Eucumbene-Tumut Tunnel, necessitated Messrs Ward and Walton spending all their time in the field advising and training the Authority's engineers in field work and assisting the senior resident engineer at Cabramurra. As a result they could not, as had been hoped, spend some of their time in Cooma. In addition the majority of the Authority's engineers associated with the contracts were placed in field positions, leaving only relatively junior and inexperienced engineers available for contract administration duties at Head Office in Cooma.

Hudson pressed the Bureau to make available an engineer with experience in contract administration and construction management. Such an appointment he argued "... would provide much needed training for the Authority's personnel in the administration and management of the T.1 contracts and would assist in building an organisation that would later operate without Bureau assistance..." (p.2)[8] Hudson's experience with USBR staff whilst on the Warragamba Dam project may well have led to his conviction that personal interaction greatly assisted the more formal means of communication and training.[9] This engineer was to take the role of a Construction
Management Consultant whose duties were to aid, advise and guide Australian personnel who had the following responsibilities in contract administration: preparation of extra work orders, change orders, findings of fact and correspondence connected therewith; recommend to the Divisional Head approval or disapproval of contractors' claims; review notices of delay and requests for extension of time under construction contracts; make initial determination as to whether delay was excusable on the basis of facts found; review contract payment schedules for major items of construction plant and equipment; analysis of contractor's anticipated production schedules and rate of encumbrance of funds under the contract; recommend organisational changes to achieve better co-ordination with the activities of the Civil Design and Scientific Services Divisions; and supervise estimating and cost analysis sections and participate in conferences with representatives of the contractor relative to all contract matters. In addition they were to prepare or supervise the preparation of correspondence in reply to enquiries from contractors and field offices for interpretation or clarification of contracts and specifications. The making of field trips in connection with these duties for the purpose of advising and guiding field officials in the preparation of data and contract modification documents, claims, procedures, relationships with contractors regarding claims, and installation and maintenance of proper claims procedure and related work was also involved. There were no direct administrative or supervisory responsibilities, rather they were of an advisory and training nature only.

On 1 October 1954, McClellan advised [10] that Mr J D Seery, Assistant Construction Engineer at Folsom California, had been selected to fill the position of Construction Management Engineer. Seery had been associated
with Bahmeier on several Bureau construction jobs in the past both within the USA and abroad.

As the 2-year period for which USBR officers had been loaned to the Authority expired early in 1956, it was decided that the Authority should seek an extension by 12 months for three or four of the USBR officers associated with contract administration and the remaining two or three experienced design engineers to assist in strengthening the Design Division of the Authority. This was subsequently approved by the USBR although there had been changes in the USBR staff in America who had knowledge of the Scheme. The duties and relationships of the engineering advisers attached to the Authority changed with the effluxion of time, but only with the agreement of the USBR. In November 1955 Assistant Commissioner and Chief Engineer of the USBR McClellan agreed that the engineering advisers should have somewhat altered roles to reflect the changing requirements of the Authority.

Whilst it is doubtful that the Engineering Advisors thought of themselves or were thought of by others as formal agents of transfer, there can be little doubt that their roles were to encourage and facilitate the introduction of processes, practices and techniques used by the USBR that were appropriate to the Australian situation.

Mr H F Bahmeier Senior Engineering Adviser, and Head of the team, who had been with the Authority since 1954 and whose assignment continued to 17 February 1958, was responsible for supervising and implementing Bureau policies and procedures in relation to other engineering advisers. He also advised the Public Works Department of NSW on the design and
construction of Adaminaby Dam and acted as Chairman of the Liaison Conferences between the Public Works Department and the Authority. With the assistance of Mr J D Seery he maintained liaison with the Bureau of Reclamation on the design work being carried out by the Bureau for the Authority. In regard to construction, his attention was directed primarily to Adaminaby Dam, Tooma Dam, and to all construction works in progress.

Mr J D Seery, Construction Management Adviser, whose assignment terminated on 6 March 1957 acted as assistant to Bahmeier in relation to liaison functions between the Bureau and the Authority on design work being carried out by the Bureau and advised and assisted in regard to contract administration, specifications, and office engineering and general contract administration. Stationed at Cooma, he assisted Bahmeier with regard to advice on both the Adaminaby and Tooma Dams.

Messrs P von der Lippe and F E Cornwell, Engineering Advisers on Design (whose assignments terminated on 5 March and 10 May 1958 respectively) were responsible for aiding and advising the Authority in the effective planning, co-ordination, and execution of design work. Although certain designations were originally mentioned in the assignments for these officers (power stations for Von der Lippe, and dams and tunnels for Cornwell), it was considered by the Authority that it was to their advantage for these advisers to be attached generally to the Engineer-in-Charge, Civil Engineering Design, rather than be segregated into the Power Stations and Dams and Tunnels Branches. This enabled full advantage to be taken of their individual skills and experience. Cornwell's experience in special and scientific studies with the Bureau enabled him to provide valuable advice and assistance in co-ordinating the work of the Scientific Services Division with the
design and construction areas of the Authority to achieve maximum utilisation of the facilities available in the scientific services area. Similarly, Von der Lippe's broad experience in the design and construction of power stations and other works enabled him not only to give valuable assistance to the Power Station Branch, but also to advise in relation to the co-ordination of this work with other design and construction operations.

The final member of the team, Mr F Goerhing, the Engineering Adviser Construction, was stationed at Cabramurra and acted as general construction adviser to the Engineer-in-Charge of Major Contracts, in connection with the administration of the contracts for the Upper Tumut development.

The functions of the Advisory Team, in general terms, comprised advice, assistance and guidance to Authority staff in the execution of the Authority's program of design and construction work. No direct supervision of design and construction activities was undertaken, however it is clear that their role encompassed supervision in a de facto sense by encouragement and suggestions of correction and variation to practice.

Specifically, the assistance and guidance provided by the Advisory Team can be said to fall into the categories of organisation structure, contracts and contract administration, construction supervision, pre and post construction planning, training and co-ordination.

**Organisation Structure**

In the early days of its operation the Authority's organisation structure, whilst not typical of Statutory Authorities[13], reflected the areas of its main concerns, investigation, assembly and completion of design data,
preparation of specifications for each development (at this early stage it was the Tumut 1 development) and the completion by day labour forces of access roads, accommodation, and the electrical and communications systems which were necessary to enable the initiation of large scale operations on construction of permanent works.

With the commencement of work under large contracts, due significantly to Advisory Team recommendations, the first of several important re-organisational steps was made in May 1954. A Major Contracts Division was established and a Chief Civil Engineer appointed to exercise general control and co-ordination over activities of the Civil Design, Scientific Services and Major Contracts Divisions. This also led to consolidation of other Divisions. Suggestions and advice concerning the functional organisation of the new Major Contracts Division were specifically requested from, and were provided by, the Advisory Team. This was especially so with regard to the proposed field organisation for the supervision of Tumut 1 Project contracts[14].

The Authority originally contemplated that the field organisation for the supervision of these contracts would contain three independent groups, one for each contract. The Advisors however recommended that all three contracts be administered by one Senior Resident Engineer located at Cabramurra (the Regional township and headquarters for the Upper Tumut construction), from where all office engineering and clerical functions required for the three contracts would be performed. They further recommended that there should be, responsible to the Senior Resident Engineer, Resident Engineers and inspection crews in charge of work under the individual contracts at specified geographic locations. These recommendations were accepted by the Authority and in addition to the Cabramurra headquarters,
resident engineering offices were established at Junction Shaft to supervise contract 20,002, and two at Cabramurra to supervise contracts 20,003 and 20,004. Other assistance was provided to the Authority by the Advisors with respect to general staffing requirements. Team member P Von der Lippe for example advised that concrete outline and reinforcement drawings for the Tumut 1 Project would total some 153 drawings which translated to 459 man-weeks (153 x 3 man-weeks per drawing) and if they were to be completed within 26 weeks then 18 people were required. Given that the workforce was 10, 8 more were needed if the construction schedule was to be maintained.[16]

In addition to field offices, the Advisory Team were instrumental in the establishment of field laboratories to deal with contracts. The establishment of these field control laboratories followed the Advisory Team's preparation of plans, policies and techniques based on their USBR experience. Indeed the plans prepared for the construction of a laboratory at Cabramurra were substantially altered because of team recommendations, from the construction of a new building to remodelling of an existing facility which resulted in a considerable cost saving.[16]

Recommendations were also made with regard to the overall arrangements and requirements for engineering laboratories with the result that the Hydraulic, Chemistry, Geology and Photographic Laboratories and workshops were finalised and constructed consistent with USBR practices and avoiding unjustifiable laboratory luxuries.[17]

In addition to broad recommendations for physical improvements many discussions with laboratory personnel of all grades took place at which the techniques of laboratory testing and research and development
as used by the USBR were described and referred to. Considerable technical information and data was obtained from the USBR by the team for use by Authority personnel. Much emphasis was placed on the value of working, as a first priority, on those practical problems which directly assisted in the investigation, design, preparation of specifications, and construction of each feature of the project. In the same way the Advisory Team encouraged Authority staff to perform library research on relevant subjects to obtain the best advice and record what had been done elsewhere before launching off on an expensive and hurried plan to solve in a short time and in a novel way, a problem that had been successfully solved elsewhere.

Further organisational changes, directed towards improvement of service, changing needs, and better inter-divisional co-ordination, were made by the Authority over a period of time, based on recommendations and influence [18] of the Advisory Team members.

The Advisors were also commissioned [19] by the Authority to complete a comparative study of costs and staffing between the USBR and the Authority. Using budget documents, progress reports and other supplementary data a comparison was made and utilised by the Authority in considerations regarding structures, levels and organisational mechanics.[20]

Not all the Advisory team's recommendations were adopted however. No amount of influence, argument or examples based on USBR experience succeeded in persuading the Authority to devolve overall technical control, records and associated procedures to regional operations.[22] These were maintained in Cooma head office.
Contracts and Contract Administration

The history of civil engineering contracting in Australia is not a long one. At least until the late 1930s, the economy was not in a position to make available large amounts of capital. What did become available came from State or Federal Governments whose policies committed them to performing development work using day labour rather than contracts.[22]

Post war years in Australia however saw a major change in the development and economic strength of the country. Population and investment grew as did Government spending [23] on developmental works. Most construction work in Australia though was still done by day labour forces, and what contract work had been accomplished had generally been on a cost plus fixed fee basis. Indeed the contracts for the construction of the initial aspects of the Scheme, Guthega Dam and Munyang (Guthega) Power Station, were of the cost plus fixed fee type covering both design and construction.

Advice from the USBR in America coupled with argument and experience presented by the Advisory Team on site in Australia were major factors in convincing the Authority that large scale construction works such as the Scheme should be undertaken utilising a schedule of unit prices contract as opposed to the cost plus fixed fee type. The Tumut 1 Project contracts were the first large scale construction works undertaken by the Authority under a schedule of unit prices.[24]

Cost plus fixed fee contracts provide for a fixed sum to be paid to a contractor in addition to the actual cost of the work. This often provides an inducement to speed and economise, for every delay keeps the contractor from another job, ties up plant, and increases overhead
costs which must be met from the fee. This type of contract has the advantage on difficult and hazardous jobs where the risks are great, that tenderers need not bid high to cover themselves against possible loss. It also lends itself to the situation whereby the cost of the job can exceed its agreed estimated cost.[25] Schedule of unit prices or schedule of rates contracts on the other hand are those in which the contractor carries out various clearly defined classes of work at stipulated unit rates. The work to be done is scheduled as accurately as the quantities can be estimated, but the actual quantities are measured in the completed work and paid for at the prices stated in the tender. These are therefore the fairest type of tender for both parties [26] in terms of costs, payments, speed of job and quality of work.

In light of the fact that construction of major works by unit price contracts was a new field in Australia, and that the Authority was pioneering this field, the assistance of the Advisors and the application of the Advisory Team's experience based on similar Bureau of Reclamation work proved to be of invaluable assistance in the successful use of such contracts.

As mentioned the Authority pioneered the use of unit-price contracts in Australia and as a result had to change the emphases placed on many aspects of its procedures and practices, not the lease of which was a greatly increased emphasis on good specifications containing complete design detail. The Advisory Team placed great emphasis on this aspect and stressed the possibilities of conflicts, delays, inferior workmanship and increased costs resulting from deficiencies and/or the omission of complete design details from the specifications. These results had been demonstrated under contract No. 20,004, where early construction of access roads was required but
where alignment and other design details were not included in the specifications. Because of this lack of design details, the work cost more than originally contemplated, took longer to accomplish, and required excessive administrative attention. Lack of firm structure layouts and dimensions for T.1 Power Station was another case.[27]

The Authority's officers as a result became more aware of the need for completing designs before calling for tenders. Indeed in the preparation of drawings and specifications for the Tumut 2 Project and the Tooma-Tumut Diversion[28], every effort was made to develop firm project arrangements and structure layouts which were unlikely to require extensive changes after commencement of construction.

The Authority at this time also had a weakness in detail design. The Advisory Team stressed [29] the necessity for thorough investigations of physical facts pertinent to construction of the various features of each project, timely programming of all features and adequate designs and specifications, in order to avoid the necessity for changes during the administration of the contract. One method developed for avoiding such modifications and changes based on the Team's emphasis was the then Chief Civil Engineer's requirement that design sections submit with their construction drawings, estimates of costs for all alterations and/or changes involved therein. This procedure allowed for careful review of all proposals which were at variance with the contract and specifications.

The Advisory Team was also instrumental in getting schedules set up for production of construction drawings and procurement of material and equipment to be furnished by the Authority and installed by the contractors. The Officer of the Civil Design Group who had responsibility for these
schedules collaborated with both the Electrical and Mechanical Division and the Major Contracts Group, to ensure effective co-ordination of effort.

The Authority had instituted an arrangement early in its development whereby monthly meetings were held with the contractors and senior staff. These meetings which were attended by members of the Advisory Team, assisted greatly in the development of a co-operative atmosphere and in the prompt and businesslike exchange of information and service by the parties involved. Here the negotiations concerning extras and changes were initiated and discussed. When agreements were reached, the preparation and issuance of contract modifications proceeded rapidly. These documents insofar as possible were patterned after the USBR's. The rough drafts were prepared in the field offices and forwarded to the Cooma Head Office for review, approval and final printing. Claims were handled in the same manner, Advisory Teams' assistance being given in all phases of the negotiations and preparation of documents.

Field assistance was provided on a full time basis, attention being given to achievement of schedules, inspections, reports and records, safety, construction procedures and interpretation of specifications.

Suggestions and recommendations regarding organisation and personnel for field administration of contracts were also issued from time to time in order that a uniformity of inspection, workmanship and quality of construction could be achieved.

The range of areas covered by USBR advisors in the general field of contracts and contract administration was therefore very broad and
included policy matters, the development of standard operating procedures, and the insistence on close attention being paid to general and technical details for application to the construction and supply contracts. This latter aspect included the need for closer examination of tenders to determine whether the contractor possessed the necessary finance, experience and construction plant to complete the job in the specified time.[31]

Liaison and communication patterns and systems within the Authority's organisation relative to contracts also received attention by the team, to ensure the development of co-operation and team work within the various sections. Economical usage of materials was encouraged and in some cases considerable savings were realised [32] by the use of locally available material in lieu of imports from overseas.

Construction Supervision

Advisory Team assistance was also provided to Authority personnel involved in inspection of construction work and the field administration of the contracts. Emphasis for field personnel was placed on the importance of co-operating with contractors to the extent of assisting and permitting them to carry out their work as efficiently and expeditiously as possible. Inspectors were advised that although the work was to be performed in full accord with the plans and specifications, their decisions should as far as possible be fair and reasonable. Probable and likely causes of contractual difficulties were pointed out and advice given regarding methods of operation by contractors, pitfalls to be avoided and means of counteracting 'tricks' that contractors often tried. Some of the main points on which advice was given included[33]:
"(a) To be thoroughly acquainted with contract drawings and specifications.

(b) Avoid causing delays by failure to issue instructions, deliver detailed construction drawings and Government furnished materials in enough time.

(c) Avoid unnecessary delays which cause the contractor extra work or added costs.

(d) In all decisions and instructions to contractors, bear in mind that it is results of work that are important, not methods of attaining the results.

(e) Be alert to unsafe practices or working conditions.

(f) Keep good records of instructions given, causes of delays, extra work performed, etc, for later use, if needed, in preparation of findings of fact, answering contractors' claims, litigation, etc, and

(g) In reviewing drawings submitted by the contractor for approval, the prime requisite being to ascertain conformity with the specification."

(p.2)

In addition to providing the advice on construction supervision in written form, team members attached to the various areas and projects regularly assisted in, and commented on, the physical examination and supervision of the projects under construction.

Construction Planning

The Advisors also gave Authority personnel assistance with the review of contractors drawings and plans for camps, construction plant, tunnel
supports, and tunnel lining forms. Plans of the contractors' cement handling plant at Cooma, the concrete aggregate processing plant at Happy Jacks, and the plant for installing reinforcing steel and concrete tunnel linings were specially considered in studies and discussions.

Contractors' construction programs were carefully reviewed by the Advisory Team with particular attention being given to control or delivery of Authority-furnished materials and construction drawings, conformity with contract provisions, consistency, proper sequence of operation for completion of the various items within the contract times, and effect on administrative and program responsibilities.[34]

Training

Closely related to the issue of construction planning and supervision was that of training. The training of Australian Engineers in America by the USBR is dealt with in detail at a later section, however it must be said that when they returned to Australia they, with continued field assistance from the Advisory Team, did much to overcome problems in the areas of inspection of works constructed under contract.

In addition to the overseas training, the Advisory Team encouraged the Authority to undertake the in-house training of other personnel mainly tradesmen as inspectors; a decision made easier by the shortage of suitably trained and qualified personnel at that time.[35]

As had been the experience in the USA, these individuals proved to be capable inspectors notwithstanding their lack of formal technical
training. The in-house courses conducted by the Authority to train inspectors lasted approximately 3 months consisting of lectures, tutorials, field exercises and where applicable laboratory exercises. Courses conducted included Survey A, and B, Field Hydrography, Welding and Radiography (for Inspectors), Mechanical (for Inspectors), Excavation and Tunnelling (Inspectors), and Concrete (for inspectors). In addition conversion courses, in Excavation and Tunnelling, and in Concrete were given to inspectors already qualified in another category.[36] The Snowy Mountains Authority trained with marked success some 200 men in several fields of civil engineering in less than three years, thereby reducing its demand for engineers[37], due largely to the recommendations and experience of the Advisory team.

Design and Co-ordination Assistance

Assistance with design and co-ordination of design both with work performed in Australia and from the Denver Office of the USBR comprised a major part of the Advisory Team's duties.

Assistance was given to the Chief Civil Designing Engineer and his staff in organising and managing the Civil Design Division, planning, programming, and executing design work performed for the Authority in Denver. This civil design work included review of the contractor's drawings for the Guthega Project (designed by contractor); review of Bureau construction drawings for Eucumbene-Tumut Project, Tumut Pond Dam and T.1 Pressure Tunnel; preparation of construction drawings for T.1 Power Station; preliminary design of T.2 Project features; review of Bureau proposals for final layout and design of T.2 Diversion Dam and T.2 Project waterways;
study of final layout of T.2 Power Station and adjacent structures; preparation of specification drawings and text for Tooma-Tumut Diversion; and review of the Bureau's proposal for the arrangement of the downstream end of the Tooma-Tumut Tunnel.[38]

Specification drawings for T.1 Power Station (Contract 20,004) were also prepared. However, they were from insufficient data base necessary to determine firm structure layouts and dimensions, particularly data on hydraulic and electrical equipment to be installed. This and other unforeseen conditions encountered required a number of rather extensive modifications to arrangement and design of the various features.[39] The Advisory Team participated in studies, field inspections and discussions on these matters, as well as design and layout studies for the other projects mentioned above.

In addition an important function of the Advisory Team was the co-ordination of design work performed in Australia with that performed for the Authority in Denver. It should be noted that the office of Authority Liaison Engineer in Denver was abolished in September 1954[40], and from that date the Bureau Design Engineering Advisor in Cooma was made responsible for maintaining liaison with the Denver Office regarding design work. From that time, excepting on matters of policy, all correspondence between the Authority and the Bureau concerning exchange of technical information, details of design work requested of the Bureau, studies and recommendations from the Denver office on structure layout and design, transmittal of drawings and draft specifications, revision of drawings, etc, were conducted through the Senior Engineering Advisor.
The engineering advisors progressively ceased duty with the Authority and returned to the USA during 1958. By the time they left design drawings and specifications had been completed and contracts let for the major part of the Upper Tumut project.

The role that these agents played in the successful transfer of technology should not be underestimated. Their technical experience and expertise was not challenged by Authority personnel and they were able to assist in the smooth implementation of practices and policies based largely on Bureau models, but modified where appropriate for Authority purposes. The close contact that was maintained by virtue of the Bureau's engineers acting as liaison engineers between the USBR in Denver and the Authority was a very important instrument in the mutual acceptance of modifications to design and specifications which inevitably happen during the life of a project.

Under the tutelage of the USBR advisors, Authority personnel rapidly developed experience in contract administration, including the new unit-price contracts, construction supervision and construction planning, both at the detail and conceptual levels. This ancillary training, education and experience building all contributed to the successful transfer.

That the advisors came from a Government undertaking also assisted in their ability to contribute immediately to the needs of the Scheme. From their experiences they were aware of how Government structures and bureaucracies functioned, of the financial and other resource constraints, and of the communication and information channels through which results were obtained.
There can be no doubt that the USBR Advisory Team contributed significantly to the successful completion of the Upper Tumut works.
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4 Department of External Affairs Cablegram 231 to the Australian Embassy in Washington 10 April 1949. Folio 1D, G.271(1).


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File G 271(1) op cit.

File G 271(2) op cit.
Just as the Scheme benefitted in terms of savings in costs and time by having the Bureau advisors "in situ" in Australia, so too did it benefit from having its own engineers in training with the USBR in Denver.

The shortage of skilled personnel in the areas required for the project, contract administration, hydrology and gauging, site investigation, road construction, dam design and construction, canals flumes and tunnels, powerhouse sub and superstructures, power station plant and equipment, switching stations, and transmission lines and distribution [1] have been mentioned previously. Recognition of this shortage of skilled manpower available in Australia coupled with the decision to recruit overseas and the time lapse inherent in such recruitment led the Authority to include in its negotiations with the USBR, training for selected Australian engineering staff. It was claimed that at this time the Bureau included amongst its Denver staff some of the world's leading authorities in engineering and related scientific fields, [2], the majority of which matched the experience requirements of the Authority for construction of the Scheme.

It is clear that the USBR possessed the technical knowledge and capability required by the Authority for the successful development of the Scheme. This satisfied one half of a requirement [3] for the successful transfer of technology; that the source possess technical knowledge and/or capability useful to the receiver. The other half of the equation, that the receiver should have complementary knowledge and capability, should understand the circumstances and potential contributions of the source, be able to demonstrate interest, and support this with its own incentives, was not capable of being immediately satisfied by the Authority because of its lack of sufficient resources with the complementary knowledge and capability.
There can be little doubt that the organisation had begun to develop its own incentives in terms of infrastructure and operating systems and that it understood the contribution the USBR could make in both the technical and training areas. In this latter regard the Authority decided to send some 100 of its engineers [4] to study and train in the various aspects of the USBR's operations and techniques in the period 1951 to 1959.

The recognition of the training role that the Bureau could play occurred in the very early days of Scheme for even before the signing of the Agreement[5] which provided for the co-operative program of technical training and assistance, the process of selecting trainees and the logistics of transport, training, and training administration had begun. This is reinforced by the fact that the first group of trainees arrived in Denver on 22 November 1951, a mere ten days after the signing of the Agreement. This was at a time when security and customs clearances and entry visas for the USA often took three months to process and approve.[6]

The practice of sending selected suitable personnel to study under the supervision and guidance of more advanced organisations was not new when it was first considered within the Authority. The USBR had been training both American and foreign students across a large range of disciplines for some time and at the time of the Authority's request was considering requests from three other foreign countries.[7] This system with its emphasis on training acknowledged the fact that in addition to the considerable preparation and technical effort required to ensure that a technology was successfully adapted to local conditions, that education, training and development of individuals utilising the technology had to be carried out. Vickery[8], in support of this notion, holds the view that ancillary training,
education and experience building are the key to successful technology transfer in that they must accompany and facilitate the smooth introduction of international technology.

In addition to assisting in the understanding and comprehension of a new technique or system, the benefits accruing to the organisation from training and development include reduced learning time to reach acceptable performance levels, improved performance on the present job, attitude formation, resolution of specific operational problems and manpower needs[9], whilst the benefits to the individual include job enrichment, security, status, and enhancement of market value. Each of these factors were important in their own way to the successful transfer of USBR technology to the Scheme.

In any learning situation, including training, education, development and experience building, there is a cumulative process in which individual adjustment involves changes that reflect and are based on earlier experiences and changes. The individuals reaction in any learning situation is conditioned and modified by what has been learned in earlier lessons and experiences[10]. In order to ensure that appropriate experiences could be built on, the educational and experiential backgrounds of all Authority engineer trainees were thoroughly examined prior to selection for overseas training to ensure a close match between training course requirements and objectives and trainee experience. The USBR was careful to tailor the training programs to match the individual work situations and areas of concern as put forward by the Authority in conjunction with the individual engineer. The training course syllabi were based to an extent on experience and intuitive analyses of the desired behavioural objectives as well as the recognition that failure to tailor courses was unlikely to yield successful results in the intermediate
and long terms.[11]

The numbers involved and the training programs envisaged by both the Authority and the Bureau changed dramatically in a relatively short period of time, from the point where two or three of the Authority's bright young engineers would be trained to gain experience in the Bureau's methods[12], through the Authority's preparedness to send up to twelve engineers for training[13], to the point where there was an acceptance that training would take place during the period of time that the Bureau provided technical assistance to the Scheme.[14] The overriding concern being that the training program as finally determined between the Bureau and the Liaison Engineer was of fundamental interest to the Authority and that it was undesirable to sacrifice diversity of training to expediency for a particular project.[15]

Having determined the training programs for each of the selected trainees, these being directly related to the Authority projects being undertaken at the time, the trainees were counselled on their obligations and the Authority's expectations of their behaviour and performance. They were expected to display the utmost diligence to their work and familiarise themselves with all phases of the work on which they were engaged. They were instructed to pay particular attention to all aspects of design including basic assumptions, loading conditions, and other special requirements because on their return to Australia that knowledge would materially aid in carrying out the works to their successful completion.[16]

The first Liaison Engineer, Pinkerton, arrived in Washington on 15 November 1951, and following discussions with the Foreign Activities
Section of the Bureau and officers of the Australian Embassy in Washington proceeded to Denver on 22 November 1951. The first group of four trainees arrived in Denver on the same day and took up duties at the Bureau on 26 November 1951, ten days after the execution of the Agreement.[17]

The orientation program for these trainees (Messrs McConnell, Hunter, Wilkin and Williamson) lasted five days and included introductions to senior staff; a tour of the engineering laboratories; discussions on hydrology, project planning, engineering geology, development of hydro electrical projects and hydraulic machinery; location selection and design of dams; a lecture and slide presentation on problems of grouting; an explanation and tour of the Colorado-Big Thompson Project; and "the inevitable publicity photographs".[p.1][8]

All four trainees were civil engineers and as mentioned, training programs were specially developed for each individual. A. McConnell trained in earth dams (3 months), spillways and outlets (3 months), materials laboratory (1 month), and field assignments (1 month). J. Williamson trained in spillways and outlets (3 months), structures and tunnels (3 months), large gates and valves (3 months), hydraulics laboratory (1 month), and field assignment (2 months). W. Wilken trained in foundations and grouting (3 months), concrete dams (3 months), steel pipes and penstocks (3 months), concrete laboratory (1 month), and field assignment (2 months), and J. Hunter trained in concrete dams (4 months), field assignment at Canyon Ferry (3 months) and field inspection and special assignments (1 month).[19]

The second group of trainees comprising Messrs D. Walsh, R. Sanders, A. Hosking and L. Endersbee, arrived in Denver and commenced their
respective training schedules on 21 February 1952. Walsh's program involved hydrology project planning (3 months), field assignment and inspection (2 months), and spillways (3 months); Sanders involved project planning (4 months), field inspections (2 weeks) and concrete dams (3½ months);

Hosking spent 3½ months in engineering laboratories, 2 months on earth dams, 2 months on field assignments and inspection, and 2 weeks on special assignments; whilst Endersbee spent 6 months on tunnels and structures, 3 months on earth dams and 3 months on field assignments and inspections. These training schedules were developed to permit the trainees to work on various phases of the design work for the Tumut Pond Dam and associated diversion systems. Thus, in addition to gaining experience on general USBR projects and work practices, the trainees specifically spent time on relevant parts of the SMA project which at this early stage involved mainly civil and hydrology works. These were also the areas in which the Authority was most vulnerable from a resources point of view.

This practice was true also of the third group of trainees who arrived in Denver during February 1952 with the following training schedules:
L.W. Gilmour and B.G. Hely, construction administration, field construction with particular reference to supervision and administration of contracts, and production control and scheduling; I.P. Sargeant, project planning as related to the work carried out by the Authority's Investigations Division, concrete dams and bridges, and field inspections; and B.J. Hannon, studying power station layout and design.

As the planning for the Scheme progressed and technical details for each section of the project were finalised with the assistance of the USBR technical advisors in Australia the requirements for training in
different areas and disciplines were identified, and trainees were selected accordingly. The first mechanical engineer trainee R.S. Franzi arrived in Denver late in 1952 to train in the mechanical design of large gates and valves, low head gates, and for field training and inspections. He was accompanied by G F Millington, a structural engineer, who trained in hydraulic design including the specialised subjects of surge tank design, water hammer problems, and stability of hydraulic systems, the hydraulics laboratory, mechanical design of gates, valves, penstocks and pipes and inspection.[21] In addition his field assignment included office and design work in a regional office, the organisation structure decided upon by the Authority for construction of the Scheme.[22] During 1953 a further sixteen trainees left Australia for Denver to study in such areas as construction and contract supervision [23], and administration, structural design, canal and project planning, materials testing (especially concrete and steel), sediment control, sampling technique and stream bed load movement.[24]

Between November 1951 and December 1954, 47 of the Authority's engineers trained with the USBR and selected other US organisations as arranged by the USBR. Training periods varied usually between eight and twelve months, the latter period being for single trainees and the shorter period for married trainees since wives were discouraged from going to the USA with their husbands. Estimates indicate that the cost per man week of training during this period was £61.[25]

Contracts for major civil works let during this period included Eucumbene-Tumut Tunnel and Happy Jacks Dam, Tumut Pond Dam and Tumut 1 Pressure Tunnel, all let to Kaiser-Walsh-Perini-Raymond, a joint venture between four American companies with a contract value of $38m; Tumut 1 Power
Station, Pressure shafts and Tailwater Tunnel let to a French group of contractors with a value of $7.8m; Tumut 1 Power Station Generators (ASEA Electric (Aust) Pty Ltd, $2.2m); and Tumut 1 Power Station Turbines (English Electric Co. Ltd $1.7m).[26]

As each of the contracts got under way there was an increased requirement for skilled engineers experienced in contract administration and supervision as well as the specialist disciplines associated with the various parts of the works in progress.

Similarly as planning for new projects and the technical detail and specifications for them became more advanced the requirements for training varied, however the numbers being trained did not diminish. It was recognised that Australian engineers required training in less well known areas as well as the more common disciplines and techniques. As long as the USBR was preparing the majority of technical specifications, operating procedures and practices and instructions, it was considered that the Authority would benefit significantly from having engineers trained by the USBR on these projects and in USBR methodology.

By 1958 the training thrust was noticeably broader due to the changing styles of construction and the progress towards finalising some of the contracts thus necessitating completion of wiring, and operations, protection and control systems amongst others. Training now involved design of tunnels, power station design, specific hydrology equipment including telemetering, hydrographic forecasting techniques and methods, power plant, electrical machinery and controls, and design of aqueducts. The training program for Mr R. Hilton, who left for Denver on 18 January 1958, provided a
good example of the specialisation of some of this training. In the broad sense he was required to visit the USBR Earth Laboratory in Denver to study Bureau classification test procedures, hydraulic and structural test procedures, records systems, report writing and report production systems, and to study and report on all new equipment and techniques. Specific aspects of the program included the study of earth dam specification requirements, processing of construction control test results from the field and earth dam design, whilst in the Earth Dam Section; X-ray diffraction of clays, selection of rock for rip-rap, rockfill, etc, and general petrography in the Petrographic Laboratory; and the observation of earthwork operations on large cuts and fills, and the placement, compaction and test operations on base and surface courses of flexible pavements whilst attached to the California State Highway Department based in Sacramento.[27]

This increasing specialisation was increasingly evident in trainee training after this time as a result both of the major contracts let and subsequent work on them, and as a result of the finalisation of design parameters for the other works to be carried out in the Upper Tumut stage and the remainder of the Scheme. Whilst trainees still undertook studies in the civil engineering disciplines increasing emphasis was being placed on the electrical and mechanical disciplines and aspects of the operations and control of the Scheme.

This was exemplified by training programs of Messrs C.W. Walker (1958) and R.H. McKay (1959). Mr Walker, an electrical engineer, spent 9 months in the USA studying in the field of automatic high speed single phase and three phase reclosure of transmission lines and of load and frequency control.[28] This period included periods of time with both the Bonneville
Mr McKay, a mechanical engineer, undertook not only training with the USBR in mechanical engineering design and field construction, but also undertook witness testing of Tucker sno-cats and other over-snow vehicles in Oregon, the observation of snow clearing practices and equipment (with the Colorado Highway Department), and factory instruction on engines and transmissions of caterpillar (Peoria, Illinois) and Allis-Chalmers (Springfield, Illinois) heavy tractor and grader equipment.[29]

Thus as the technology required for the achievement of the optimum solutions to specific situations varied with the situations, so too did the training.

Eucumbene and Tooma Dams, the contracts for which were let in May 1956 and May 1958 respectively, were earthfill dams, and the training required by the Authority for its engineers on these projects differed from the training required for its engineers on later dams which were concrete arch (Tumut Pond), and concrete gravity (Tumut 2, Tantangara, and Happy Jacks) dams.

From the commencement of the traineeship scheme in November 1951 until its cessation in January 1962, 108 Authority officers undertook formal in-service training with the USBR. This training was designed as far as possible to match the experience and abilities of the trainees and the role that was expected of them on their return to Australia.

Whilst everything did not go entirely smoothly with the traineeship
program, the trainees and the Authority did obtain major benefits from it. The trainees gained experience in USBR techniques, practices and procedures, and acquired knowledge specific to design, planning, construction and operation techniques. They learned how to adapt these techniques and systems to the conditions existing in the Snowy. [30] Their contact with Bureau officers also assisted in a direct communications flow at an individual level. The Authority benefitted from the program, certainly because it received back highly trained staff, but also because the trainees worked on Authority design issues whilst with the Bureau. The Authority also gained additional benefit from the trainees' experience with the Bureau because their exposure lessened the typical resistance to change which occurs when technology comes from an external source.

The Bureau also received a benefit from having the trainees work with them because the trainees undertook Bureau work including design whilst still being paid by the Authority. In fact the trainees did Authority and other work for the Bureau whilst they were being paid a salary and the Bureau was being paid to complete the design work, both paid by the Authority.
References


2 USBR Report. *op. cit.*

3 Stuyt, L.B.J. in Gee S. *op. cit.*


5 USBR - SMA Agreement.


7 Smith-Mundt Act, Section 402 *op. cit.*


13 Cablegram No.406, Department of External Affairs to Australian Embassy Washington 25 April 1951 (sent in order to satisfy a training slant and thus avoid Public Law 402 if necessary) Folio 32, G271(1).


16 SMHEA Notice on Assignment for Engineer Trainees in regard to the Agreement between the USA and Australia for Training of Australian Engineers and Technical Assistance to the Authority by the Bureau of Reclamation, Denver. June 1952.


19 Ibid.
20 Letter, Lang, T. to Hudson, W. 17 December 1951. Folio 120, G271(1).
22 For a more detailed explanation of organisation structure see Chapter 8.
24 Memorandum, Harris, N.A. to Campbell, D. 18 February 1953. Folio 151, G271(2).
25 Memorandum, Chief Accountant to Assoc. Commissioner. 13 July 1955. Folio 81, G294(1).
28 Ibid.

File G271(1) op. cit.
File G294(1) op. cit.
File G271(2) op. cit.
THE ROLE OF THE INFRASTRUCTURE

One of the pre-requisites for successful technology transfer is an effective system for ensuring that the information flows between the possessor of technology and the user of that technology. This delivery system or infrastructure has been described as the key linking network or vehicle between the producers and users of technology.[1]

The infrastructure functions to bring perceived or articulated user needs to the attention of funders and research producers, and in turn delivers research results or technology to meet stated user requirements. One way of understanding how the infrastructure works is to follow the studies of Anyos.[2] His model highlights the various functions of the infrastructure by broadly defining the four categories of participants in the delivery systems of industrialised nations as being funders or entrepreneurs, research and development producers, linking agents or brokers, and users.

Funders or Entrepreneurs occur in both public and private organisations that provide financial resources for the development or adoption of technologies. In the USA this role is taken primarily by Federal Government Agencies such as NASA, and large private sector producers such as IBM, GM and AT & T. In the context of the Snowy Mountains Scheme it is clear that the funder of the original research was the US Government via its agency, the USBR. The Australian Government paid for the use of this technology but should not be considered a funder in this sense.

Similarly, the Australian Government and the Snowy Mountains Scheme could not be considered "research and development producers", a category which includes government laboratories, universities, research institutions and private research and development activities, for even though the SMA
conducted model simulation and other tests in its scientific services laboratories (see chapter 6), the primary research and development was carried out by the USBR, funded entirely from US Budget allocations.

It is not until the categories of "Linking Agents or Brokers" and "Users" are considered that the involvement of the Australian Government and the SMA becomes clearer.

Anyos' third category "Linking Agents or Brokers" include those public or private organisations or individuals that expedite the movement or diffusion of technology within or across national boundaries. These include functional interest groups, professional organisations, trade associations, consultants, and any others who work to utilise new technologies on existing problems. It is the broker's role to identify applications within the public and private sectors. Of course brokers need to recognise that utilisation usually involves modifications and adaptation to meet the expressed needs of the user.

The Australian Government, based on recommendations from officers of the SMA and the relevant Ministers, acted as the Linking Agent or Broker through identification of the stock of technology available to it from within the USBR. This role was continued by becoming party to the assistance Agreement, and by guaranteeing that resources would be available and expended to cover the costs of accumulating and organising the information. These resources which were originally estimated at between £166 million and £185 million [3] (which included transmission) and subsequently adjusted to between £170 m and £200 m [4] were made available by successive Australian Governments following borrowings from the International Bank
totalling some £204 m.\[5\] These figures reflect original estimates for the total Scheme (not just the Upper Tumut works), and were again finally adjusted to total $800m. [6]

The Government charged interest on this loan at a rate equal to the long term bond rate (originally 3 1/8%) and repayable over a period of 70 years from annual charges associated with the production of electricity paid by the States of NSW and Victoria and the Commonwealth in proportion to their entitlements to electrical energy.

The amount provided for the development and adaptation of appropriate technologies through the USBR was $3.3 m for the period 16 November 1951 to 30 June 1971.\[7\] These charges represent USBR assistance in terms of designs and specifications, operating records and instructions, construction drawings, training of Authority staff, USBR advisors attached to the Scheme in Australia, and model development testing and simulation.

At the same time the Authority acted as a Linking Agent/Broker through the provision in Denver of Liaison Officers who were either engineers or administrators. This service was pursuant to paragraph 3 of the Agreement\[8\] which provided for the maintenance in Denver of a Liaison Engineer as the Authority representative to co-ordinate technical phases of the work being performed by the USBR including the training program. This Engineer was to be assisted by an Administrative Officer responsible for all administrative matters related to the maintenance and well being of the engineer trainees assigned to training duties in the USA. This original recommendation was however modified so that there were not always two liaison persons in Denver at the same time. In the period 15 November
1951, when Mr I.L. Pinkerton the first Liaison Engineer arrived, to February 1962 when the Denver office was closed, twelve Authority officers acted in a liaison capacity, usually for a period of some 12 months.[9]

This requirement by the USBR to establish appropriate co-ordination mechanisms with Denver was based on their experience that the sending of papers, specifications, and procedures do not of themselves facilitate effective transfer. To transfer know-how, much of which is not written down, there is frequently no substitute for person to person training and assistance.

The role of the liaison representative went further than merely co-ordinating the relevant training programs, for often these programs were varied at short notice to take advantage of specialised training and inspections of USBR and other facilities which arose on an 'ad hoc' basis but which were of benefit to the trainee and the Scheme. Variation also occurred from time to time to match specific situations which occurred in Australia after the trainees had departed for the USBR in Denver.

In addition it fell to these liaison officers to provide the necessary administrative and personal support so often necessary with overseas training. These functions included security and customs clearances, entry visas, accommodation, banking and pay details, travel both within the USA and return to Australia, counselling, progress reports on training and a range of other minor services including telephone connection and rental payment, and provision of cutlery and linen for the rented apartments.
Some of the trainees remained in the USA at various times to take over the duties of Liaison Officer. This added another dimension to their training by virtue of exposure to the administrative requirements of maintaining the training scheme as well as exposure to the broader administrative aspects of the USBR systems of operation including style, procedures and practices, filing systems, referencing, paper flow, and decision making processes. These concepts and practices returned with them to the Authority.

Of the Liaison Officers who served in the USA, most went on to senior administrative or engineering positions within the Authority on their return. Mr K.E. Andrews, who was in the USA from October 1953 to July 1954, became an Associate Commissioner, and Mr P.G. Collins, October 1956 to September 1957, went on to become Associate and then Acting Commissioner of the Authority.

The final category in this model refers to "Users", i.e. those who benefit directly from the transfer of a given technology, usually the private industrial sector, and those who benefit indirectly, the ultimate user or consumer of the product or the technology.

The User assists in the delivery of technology by still further adapting the technology for other uses, as well as those uses for which it was originally transferred. Continued usage and modification reinforces the appropriateness of choice of technology and effectiveness of transfer. Of course in the case under consideration it would have been most surprising if the users of the technology had indeed not utilised it for the purposes for which it was intended.
Whilst the above model is useful in understanding some aspects of the role of infrastructure in technology transfer, it is less useful when examining the role of the structure and management of an agency responsible for the successful transfer of technology which does not conveniently fit into one of its four categories. This is the case with the SMA.

Characteristically, the transfers of technology to developing countries are "new track transfers"[10], that is, the new technology cannot be transferred without modification into an existing activity. In order for the new track to be utilised there must be brought into being an institutional, technical and cultural infrastructure as a context for organisation and operation. Such an organisation or institution is according to Strassmann[11], one of the determinants of the success or failure of technology transfer.

The Snowy Mountains Hydro-electric Authority was created in order to achieve the successful construction of the Scheme by whatever means and utilising whatever methods it could within the provisions of its enabling legislation. As has been seen it was quickly recognised that there were insufficient trained and experienced engineers in Australia at the inception of the Scheme's development and that to undertake the necessary design and planning to satisfy the timeframes for development within Australia was clearly impracticable. An appropriate organisational structure thus had to be developed that would facilitate the transfer of technology via USBR design, development and other technical assistance from the USA, the training of Authority engineers in the USA, and USBR advisers attached to the Scheme as well as carry out the planning and construction of the Scheme.
In this situation the Australian government was again to use the experiences of the USA. According to Wettenhall[12], the Tennessee Valley Authority was used as an exemplar in a number of ways leading up to the creation of the SMA. These included:

(i) "The NSW Parliament received a special report on it after an overseas visit by the State Premier in 1945;

(ii) the legislation creating the TVA and the lawsuits by which it had been challenged were the subject of a special study by the so-called Officers Committee under the chairmanship of the Federal Director-General of Works, Dr L.F.Loder;

(iii) there was much further discussion of the TVA experience when the bill to create SMA was before the Federal parliament; and

(iv) it was no accident that the title 'Authority' was used rather than the more familiar 'Commission' or 'Board'."(p.87)

The TVA set up in 1933 by the US Federal Government covered the complete Tennessee Valley watershed, covering 40,000 square miles and including portions of seven states[13]. It was established as part of President Roosevelt's "New Deal" programme, and was justified to the US Congress by its defense functions and capacities. In commending the creating legislation to Congress, he indicated he was seeking a corporation:

"... clothed with the power of government but possessed of the flexibility and initiative of a private enterprise,"
charged with the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and its adjoining territory for the general social and economic welfare of the Nation . "(p.49)[14]

By the late 1940s the TVA had won world wide acclaim for its achievements in the development of the region encapsulated in its legislation. Social studies were also beginning to suggest that the corporate dedication to, and consideration of, the interests of the people of the region were more than compensating for the loss of direct external Government control that arose from its operation as a public corporation.[15] Needless to say the TVA utilised the services of the USBR during its construction and development stages. Its charter, structure and role was such that it was receptive to the technical knowledge, techniques and information flows from the technological stock possessed by the USBR.

The success of the TVA and the role played by the Government in its development were not lost on some Australians. Casey[16] described it in 1949 as a development stimulator, commenting that:

"Certain forms of Government activity can play a most valuable part in stimulating private enterprise . . . Lord Keynes has said that the sphere of Government is not in doing something that is already being done - and doing it a little better or a little worse - but in doing those things that are not now being done at all . . . Future TVA's may well have nothing to do with flood control or the generation of electricity - but the valuable thing that America has taught us is the idea behind TVA - that the creation of conditions under which
the energy and the creative imagination of countless individuals can be released, so that they can get a move on." (p.7)

That the SMA was established as an Authority and not as a department of the executive government (or ministerial department) allowed it greater flexibility in financing, staffing, procurement and other elements of administration than was possible under conventional machinery. This ensured that it was capable of being a sufficiently powerful agency of action and coordination[17] to assist rather than act as a barrier to, the intake of superior technology.

The Authority's organisation structure was headed by a Commissioner[18] and two Associate Commissioners who were directly responsible for the five engineering groups which comprised Investigations (Engineering and Economic), Civil Engineering Design and Scientific Services, Major Contracts, Electrical and Mechanical Engineering, and Field Construction, and two service groups comprising Finance and Administration, and Stores and Supply.[19]

The initial ideas presented for each project were examined by the Investigations Group engineers. After a general feasibility study, a broad outline of the work was programmed and preliminary investigation begun. Economics were carefully examined and alternative propositions developed following which further investigations were undertaken in greater detail. These included the collection of data on stream flow, climatological conditions, snow cover, water quality and sediment concentration, and entailed field surveys, aerial photography, photogrammetry, map-making, geological exploration and drilling for geological core. Obviously, the more information that
could be obtained at this stage the more comprehensive and more soundly based would be the preliminary designs.

The information thus obtained was then usually consolidated in report form in which the general overall design of the project was suggested. After further examination a particular general design was adopted and the work taken to the next stage of its development.

Working within the scope of the general design, the Civil Design and Scientific Services Group engineers and scientists produced detailed designs of the various sections of the project. This often necessitated further scientific studies covering such fields as soil analysis, weld-parameters, model studies of water flow and river bed movement, concrete studies, and so forth. Many of the engineering problems which emerged at this stage and also in the earlier investigation stage were solved by utilising the Authority's General Electric System 225 computer facilities.

During this stage, work began on detailed estimates and cost analyses, and on the preparation of tender documents and specifications. The Authority called on the services of its consultants, the USBR, to act as engineering auditors, which ensured that the work was based on sound engineering and technical practices.

As the final designs were approved, the Civil Design and Scientific Services Group prepared the detailed contractual drawings and documents. Contracts were advertised, and tenders received and examined. The contracts were then placed with civil construction organisations.
Due to the magnitude of many of the contracts (some of which exceeded $40 million in value), this contract work involved the employment mainly of overseas contractors, but most of the staff and all the working teams were Australian residents, many of them new migrants. In order to reduce the time of construction, the Authority's planning was based on its own field construction forces undertaking the building of access roads to the project sites, the provision of initial accommodation for the contractor's work force and the supply of power for construction purposes.

The Field Construction Division was therefore responsible for road construction and heavy plant necessary for this work and for erection and maintenance of accommodation on the works sites. It also controlled the Authority's three aircraft, which had a total seating capacity of 23, and which were used for the rapid transportation of personnel and supplies. The aircraft were also used extensively in aerial survey work.

The Major Contracts Group was responsible for the management, co-ordination and supervision of major civil engineering contracts. These engineers collaborated closely with the design engineers in ensuring that technical adequacy and proper engineering standards were maintained during the course of the contract work. Since the start of major contract work, this group supervised the construction of contracts worth over $400 million by the late 1960s.

In hydro-electric engineering it is customary for the civil works to be separated from mechanical and electrical works insofar as contractual work is concerned. The Electrical & Mechanical Group, however, worked
closely with the civil design engineers in design, cost estimates, material estimates and equipment specifications for the electrical and mechanical plant installed in civil works. This group was also responsible for the installation of the plant and for the operation of the Authority's power producing installations and systems not under the control of the Snowy Mountains Council - the body responsible for the general operation of the Scheme's power stations.

The Finance and Administration Group was responsible for the analysis, appraisal, development and administrative organisation, methods and general procedures for the effective control of finance and administration throughout the Scheme. In addition it provided protective services, medical and legal services and general printing facilities as well as transport control of a large fleet of vehicles and general services to the other groups.

Finally, the officers of the Stores and Supply Division were responsible for the purchase of all supplies and for the disposal of surplus stores and equipment. Their duties include arrangements for import licences, custom clearances and duty refunds.

The aim of this structure was to pinpoint responsibility for progress and expenditure on each item of the works to one of the above groups irrespective of where the work was carried out and at the same time to ensure that there was economical co-ordination of all work being carried out in any one location.

To fulfill these requirements the functional form of organisation was adopted whereby the responsibility of each group was explicitly defined.
Wherever the function of that group was exercised, the methods and procedures were in accordance with the direction of that group. For co-ordination of work within any region, a Regional Engineer or administrative officer was appointed to exercise functions which, to a large extent, were similar to those of the Authority (Commissioner) for the whole of the Scheme. Responsibilities thus included general discipline, adequacy of accommodation and meals, co-ordination of transport, and overall utilisation of labour. This bureaucratic structure closely paralleled the structure of the USBR with its high degree of structure of activities including the division of work into specialist jobs, the establishment of routines and procedures and the formalisation of them in written record,[20] the concentration of authority, and the control of workflow by line as opposed to staff personnel.[21]

Mention was made in the discussion of the Anyos Model[22], of the role of the Authority's Scientific Services Laboratories which whilst not being regarded as prime research and development producers played an important role in the successful transfer of technology from the USBR. These laboratories fulfilled three main functions: the elimination as far as possible of the unknown or unforeseeable conditions inherent in all projects, such as dam foundations and power station excavations; control over the quality of materials and workmanship; and the preparation of the grounds for the application of advanced engineering techniques to the design and construction of structures.[23] The types of work undertaken to fulfill these functions included the investigations of geology and construction materials during the planning stage of the projects, the use of scientific methods and model studies to find solutions to design problems when these could not be solved by mathematical analyses, and the application of quantity
and quality control tests to construction materials and workmanship. The high standard of these facilities were such that the laboratories were registered by the National Association of Testing Authorities in several fields.[24]

In addition to the provision of special services, e.g. photographic facilities and model and instrument workshops, the laboratories also provided training for specialised personnel such as inspectors, hydrographers and survey staff, and post graduate training for engineers and other professional staff. Many of the staff of the Scientific Services Division which included the Laboratories, had been trained by the USBR under the traineeship program (mentioned in chapter 7) in the professional techniques, analysis, documentation and methods which they used as the basis for training the other personnel mentioned above.

The centralised location of the laboratories, within easy access of both the head office and the field construction operation, followed the USBR practice, and was an important factor in ensuring the successful understanding and integration of operations. It resulted for example in the design engineers being able to observe model experiments being carried out in the laboratories on their behalf. Similarly construction engineers kept closely in touch with tests on cements, sails, steels and other construction materials. An important outworking of this centralised location was the effective exchange of information, and increased interest and confidence that built up between the laboratories engineers and scientists on the one hand and the design and construction engineers on the other. This exchange was further enhanced by the presence and participation of the USBR advisers.

The elements of the Anyos model can be seen to be present within
the SMA. However the important role played by the infrastructure in terms of its assistance to the technology transfer process is better understood by emphasising the elements within the delivery system such as finance, the holders of the stock of knowledge, the organisational structure of the Authority, the interaction between the various parts of the structure, and the individuals within the system. There is no doubt that without an effective infrastructure or delivery system, the transfer of technology from the USBR to Australia and from the initial point of contact to other aspects of the Scheme would not have been as successful.
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3. Prime Minister Chifley in Digest of Decisions and Announcements No.141. 9 January 1949.


8. The Technical Training Agreement between the USBR and the SMA.


17. Solo, R.A. op. cit.

18. On appointment Mr (later Sir) William Hudson was said by his wife to be the highest paid Public Servant in Australia. Video Men of the Snowy. Peter Luck Productions. 1983.

19. Dann, H.E. Background Notes on the SMA. Internal Authority manuscript.

21 The USBR Advisors on site complained that the Regional Engineers and other line managers did not have enough decentralised control. See Chapter 6.

22 Anyos, T. In Gee S. op. cit.

23 Dann, H.E. op. cit.

24 Dann, H.E. op. cit.


File G271(1) op. cit.
CONCLUSION

The foundations for the acceptance of a development such as the Scheme may be found in the Commonwealth Government's position with regard to its post war reconstruction responsibilities. Reconstruction is not a single subject in itself but rather goes to the aspirations of the community for a better way of life, and thus involves the whole complex of social, economic and political arrangements of that community.[1]

As early as 1943 Prime Minister Chifley [2] was announcing that the first duty of the Government must be to the men and women of the fighting forces. In order to address that duty and provide new jobs for them and munition workers, primary production based on potential markets at home and abroad had to be rehabilitated. Farmers had to be given stability of income, farming methods had to be made more efficient, and secondary production capacity had also to be increased. The principal matters in this program were water conservation and the extension of electrical facilities.[3]

The decentralisation of munitions production in which more than £11 million had been spent in over 35 Regional centres providing factories, plant and jobs for the local population was cited as an example of the benefits to be gained[4]. This base on which peace time activities could build for the advancement of Australia was said to be dependent on the supply and distribution of electric power.

When the proposals for the development of the Scheme first formally came to the notice of the Government in 1946 [5] it was recognised that such a scheme could significantly assist the process of reconstruction, and that in view of Australia's limited water resources, the final decision
on the use of the river system had to ensure the maximum benefit for Australia generally. In releasing a report on the diversion of the Snowy River, Lemmon commented that by exploiting the full potentialities of the Snowy River the shortages of power that existed in New South Wales and Victoria and the need to provide for rapidly increasing demand brought about by continuous industrial development, could be met. If these potentialities were met, power for NSW and Victoria would be ensured well into the future, as would water and thus an extension of the existing irrigation systems.

In his address to Parliament, which was widely reported in the media, Chifley[6] announced that proposals to divert the Snowy River only recently discussed with the various State Premiers were "... of such magnitude, and of such great national interest ..."(p.32)[7] that they had to be discussed forthwith. Not only because such a development would be very costly, but also because the proposals would mean the production of power at half the cost of coal stations, less amounts of expendable coal would be used, more water would be supplied, and the power would be produced away from the cities so that key industries and research requiring considerable power could be undertaken in relative security. He went on to remind people that:

"One of the Commonwealth Government's early policy decisions was that dealing with the decentralisation of industry. Cheap reliable power provided in congenial country areas would provide an incentive to decentralise industries especially those dependent on agricultural pursuits. A scheme so vast and so beneficial is a national asset in the fullest sense of the word. It would be one of the greatest projects in the
Following Cabinet approval on 22 May 1949, Chifley announced that legislation would be introduced to Parliament enabling the establishment of the Snowy Scheme, a two-sided plan providing for vast supplies of new power and the immense decentralisation of industry and population.

Reconstruction and development activities aimed at improving the national economy and the lifestyles and welfare of the community at large, are never costless. In the final analysis a Government has to strike a balance between the often non-quantifiable environmental and social values, and relatively straightforward economic values.

In the planning of most major developments, at least in recent times, some assessment of the economic viability or cost-benefit, has played a role in the final decision to proceed or not. The objective of cost-benefit analysis is to determine whether the benefits derived from a project outweigh the costs incurred. In order to achieve this objective, the costs and benefits have first to be identified, and then ascribed a monetary value. One criticism of cost-benefit analysis is that not all costs and benefits can be or are identified, nor can they always be quantified. As well as the direct costs and benefits, a number of other factors have an impact on the analysis; these include the time period adopted, the discount rate selected, the decision criteria, external costs and social costs as well as a number of background assumptions, both stated and unstated. All these factors require a judgement to be made, often on little or no evidence, but once they have been expressed numerically and then manipulated according to formal rules they tend to be assigned an objectivity and certainty.
The first comprehensive cost-benefit analysis of the Scheme was contained in the Final Report by the Commonwealth and State Officers, 1950.[12] Prior to this, earlier assessments appear to have taken the form of suggested benefit statements with little indication of the indices, tests and measurements on which projections were based. Figures had been produced of course for the various State Committees and the Joint Working Parties prior to announcements in Parliament of the benefits of the Scheme, however it was pointed out that whilst the degree of accuracy was ample for preliminary studies it was "... by no means adequate for the complete designing of the development..."(p.41)[13]. Notwithstanding these types of cautions it was announced in Parliament that the Scheme could irrigate an additional 300 000 acres for a gross annual return in the value of food stuffs of at least £20 million, and ultimately 750 000 horsepower [14], with a consequent saving of expendable coal reserves. Differing initial proposals lead to differing costs and benefits being described, however in introducing the Snowy Mountains Hydro-electric Power Bill to Parliament in 1949, it was stated that the Scheme would ensure annual production of some 1 720 000 kW, almost as much as the total capacity of all power stations in Australia at that time.[15] Moreover it was stated that this power could be produced at about half the cost of thermal power generation representing a saving of 4 million tons of coal per year or about one third of the output at that time.[16] In addition to the power component, 1.8 million acre feet of water would be made available, equal to some three to four times the amount then used in the Leeton-Griffith irrigation area.[17]

In their statistics for the recommended developments, the Committee of Commonwealth and State Officers put forward information based on figures which had not been definitely established, and were preliminary.
and indicative in nature. With regard to power generation, whilst it was intended that the Scheme would work in conjunction with steam (thermal) stations in the States, the economic unit of capacity had not been completely studied "...due to the limited time available and to the lack of data and staff ..."(p.29)[18]. These tentative values for maximum demand and installed capacities were used however to assist in the determination of the costs and economics of the proposal. Tumut 1 Power Station was given the approximate figures of average head of 980 feet, an average flow of 1,250 cusecs, an installed capacity of 320 000 kW, an average output of 86 000 kW and a load factor on installed capacity of 27%, whilst Tumut 2 Power Station was accorded the approximate corresponding figures of 920 feet, 1320 cusecs, 320 000 kW, 85 000 kW, and 27% load factor.[19]

A similar situation was stated to exist with regard to the benefits and availability of increased water resources. A close determination of the total extra water available for irrigation in the Murrumbidgee and Murray Valleys was not made because of "... a shortage of time and staff"(p.30).[20] However even with additional data on the monthly diversions to the Murray and Tumut Rivers made available by the Hydro-Electric Sub-Committee, a considerable amount of work was stated to remain "... to determine how effective the proposed storages will be in regulating the water for irrigational use and whether any additional storage will be necessary."(p.30)[21]. The average water available each year due to diversions alone to the Murrumbidgee was estimated to be 565,000 acre-feet per year of extra new water whilst the total average extra water available for irrigation use (by both diversion and regulation) was tentatively approximated at 1 400 000 acre feet per year [22] in the Murrumbidgee Valley. These figures apply only to the Tumut Proposal. The total Scheme statistics
being 2 620 000 kW of power production and 2 300 000 acre feet of extra water for irrigation. [23]

Costing for construction of the Scheme was not frequently raised in the Parliament however the figures of £65m [24], £166m [25], and £185m [26] were mentioned at various times. The calculation of these costs was based on fairly rudimentary information and varied according to the alternative being put. For example, the costs of diversion of the Snowy to the Murray River as finally put to the Government were based on the proposed diversion costs of the Murrumbidgee which were first prepared in 1939, updated in 1944 by simply adding 30% to the civil engineering construction items generally and again in 1947 by re-estimating at the then current rates for the cost of power stations and transmission lines, but not re-doing the whole calculation. The estimates were reviewed in 1949 to reflect the considerable increase in the costs of labour and materials. The Committee also expressed the view that:

"Any increases in costs due to rising price levels may be expected to be accompanied by similar increases in the value of power, thus the economic comparison should be more or less unaffected". (p.32)[27]

The rates used for the estimates for the dams as with other civil engineering works, were increased in 1948 by a notional 33% above the 1944 rate and by 75% above those of 1939. [28]

The attempts to provide a cost-benefit analysis for the Scheme highlight many of the problems associated with such an analysis. All the costs and benefits cannot be known, included or measured. In particular consideration of environmental and social welfare factors are almost impossible to quantify.
whilst still having a significant bearing on a decision to invest in a particular project. In fact it could be argued that it is impossible to ascribe values to costs and benefits at all, since they lie in the realm of conjecture rather than an objective scientific exercise. This is particularly so in the case of the defense considerations and arguments put forward in support of construction of the Scheme.

The use of cost-benefit analysis in technology assessment is really a political act and as Johnston says "produces a spurious mathematical precision for very imprecisely known relationships".(p.120) It is thus apparent that the rationale for building the Scheme included a large component that was not quantifiable. Indeed much of it had to do with the psychological values to the nation of inspiration and confidence, especially as they related to the momentum of the national economy, and the provision of jobs.

Information relating to the costs and benefits of the Scheme is documented in a number of different sources and is at least capable of some degree of analysis as shown by those who question the economic rationale for the Scheme's construction and existence.[30] This information is however retrospective, achieved by attempting to measure now those benefits only predicted prior to and during construction, and costs which utilise different methodologies and factors to the original.

Just as the analysis of the Scheme's costs and benefits provides some insights into the rationale behind the Scheme, a similar examination of the significant but little acknowledged role played by the USBR may prove insightful. A cost-benefit analysis of the role of the USBR is however a far more difficult exercise especially given the lack of recognition of
the role they played. Apart from acknowledgements and comments contained
in Annual Reports of the Authority until the late 1950s, no other documenta-
tion on the Scheme has made more than a fleeting reference to, or acknow-
lege of, the contribution made by the Bureau.

It is not generally well understood that when the Authority was
brought into being it had to face up to an immense amount of detailed
investigation and design work, a task which was estimated to take well
over 100 engineers some years to complete.[31]

On the establishment of the Authority a decision had to be made
which of two courses would be followed. Would it on the one hand concentrate
on investigation and defer construction for two or three years until designs
had reached an advanced stage, or on the other, carry out investigations
and preliminary construction work concurrently. It is history now that
the latter course was adopted.

In the original documentation supporting the use of the USBR it was
stated that by them undertaking the design of the Upper Tumut groups
of works, to the stage of compilation of specifications and contract drawings
so that contracts could be let, Authority staff could then concentrate
their efforts on work which would otherwise not have been completed
for some time. Further their assistance was said to be an important factor
in expediting the supply of blocks of power from the Scheme, and that
the probable costs would be $250 000, but that this estimate was very
approximate.[32]
In reply to a question (from Casey) regarding the length of time until the Upper Tumut works were complete, Hudson sent an urgent telex advising that the normal program would take some 8-9 years giving about 250 000 kW with the second station two years later bringing the total for the Upper Tumut work to about 500 000 kW. He further advised that as an urgent defence measure all U.T. works could be completed within six years by adopting unorthodox methods for placing overseas contracts. In continuing to stress the defence aspects he stated that power demand in combatant countries increased 50% during the early stages of World War 2 and that if war broke out again in the next few years Australia would not be able to meet the increased power demands unless appropriate steps, including expediting the Tumut Works, were taken straight away.[33]

This approach was supported by Casey who agreed that use of the USBR would allow the Scheme to go ahead faster on the design side and make it unnecessary for the Authority to recruit a large number of high level design staff. Although the USBR would do the work at cost, rates of pay were much higher in the USA than Australia, it was believed on net balance that the work would actually cost much less and would be done much quicker than the Authority could possibly do it. [34] In supporting this approach both the practical and political importance of associating with a technical branch of the United States Government was stressed. It was stated that:

"... it is clear that any work undertaken by the USBR would always be of exceptional value to us, quite apart from the rate at which the actual project itself may be carried out. The design work will always be an essential pre-requisite of the actual development work and we
will save our available resources of Australian technical manpower if we can get the Americans to do this job for us". (p.1) [35]

It was estimated that the total cost of the design work would not exceed $250,000, spread over two financial years. [36]

As discussed in Chapter 5, it was agreed that the Bureau would carry out all design and specification for the Upper Tumut Works to the stage where construction tenders would be called (modified Scheme C) at a final estimated cost of $800,000. In this equation it should be remembered that a unit of work in Australia costing £1 would cost $5 in America. [37] It was also agreed that the Technical Training Scheme would go ahead at an estimated total cost of some $80,000. However as early as 1953 the Authority was seeking further assistance from the Bureau[38], extending to the general review of the proposed layout, and design contract and construction drawings for large sections of the T2 project. This additional work was estimated at a further $375,000. During 1956 the Bureau was again requested to undertake additional work, this time in relation to the Eucumbene-Tumut Tunnel, and by the end of 1958 had undertaken still further work to the value of $245,500.[39] The majority of work covered two major peaks, 1953-4 and 1958-9, after which work dropped away significantly.

Notwithstanding the original intention to only involve the Bureau in the short term, the last accounts were received from them in the last quarter of 1970. The total cost of Bureau services, not including costs incurred in Australia, was $3,317,695.76.[40] This sum included training, designs, specifications, records, contract drawings, operating criteria and instructions, analysis of data, model testing, observers, administrative
overheads, liaison administration, and a special standing charge. The parties ceased their formal arrangements in 1974 when the Bureau remitted the remainder of its advance from the Authority ($1,555.67) following a request from Commissioner Dann. [41] This cessation of formal arrangements did not however diminish the range or rate of informal contact between individuals at a number of different levels within the respective organisations. Indeed these contacts, which are virtually impossible to quantify, are among the benefits to result from the involvement of the USBR.

The benefits of utilising the services of the Bureau should be seen as applying at a number of different levels. At the most obvious level the assistance of the USBR in the design of certain of the works enabled contracts for parts of the Upper Tumut works to be advertised and placed at least eighteen months to two years earlier than would otherwise have been possible, [42] and tenders for the final construction were also able to be advanced, [43] During this period of the 1950s shortages of appropriately skilled and experienced engineers and technical personnel were being experienced not only in Australia but worldwide, and:

"... the inability to attract them to Australia would have had serious consequences (for the Authority) if not for the Bureau undertaking a large portion of the designs for the Upper Tumut works". (p.21)[44]

What was also obvious was the assistance given in what could be called hard copy, including drawings, designs and specifications; contractual documentation and procedures; written operating and maintenance instructions and procedures; results of research and tests including model tests; written analysis of data, and critiques and recommendations. The Authority still
utilises the operating and maintenance manuals, and calculations developed by the USBR, which provide the foundations for the day to day operations of the Scheme. Though these documents and analytic models have been rewritten under the Authority's banner, they draw almost exclusively on the original USBR documentation. The original, and fundamental design drawings too are maintained because they provide the base from which minor modification works drawings are produced. It should be noted however that there has been no significant modification to the design or operation of the Upper Tumut works to that which was originally specified by the Bureau.

Advice from USBR personnel took both the formal and informal formats. Their formal advice often closely resembled instructions, but also went to written recommendations and suggestions. The emphasis on local management of projects and acceptance of responsibility by those on site, which was strongly argued for by the USBR consultants, and originally introduced during the construction of the Scheme, has recently been re-introduced to the Authority. This followed a review by external management consultants who recommended that the existing matrix and corporate management styles were not appropriate for an organisation whose main areas of activity were decentralised, and thus should be administered by local management with support and advice from the head office.[45]

Similarly, the use of the new form of contracts utilising a schedule of unit prices as opposed to the cost plus fixed fee type, was introduced largely at the behest of the USBR and proved to operate most effectively during the construction of the Scheme. This type of contract has now become the preferred model for civil construction contracts in Australia
both because of its obvious benefits and because many of those who used this type of contract with the Scheme have gone on to do major civil and construction industry contract work both in Australia and overseas. This latter group includes such organisations as Thiess Brothers, John Holland Constructions, Concrete Industries (Monier), Humes Ltd, and Allied Constructions Pty Ltd. [46]

The Scheme also gained benefits both formally and informally from Authority trainees who studied in Denver. That they took copious notes and copies of relevant systems and procedures is beyond doubt. However they also benefitted from the unwritten guidance, counsel, suggestions and advice of Bureau staff. Hudson commented on the fact that the training "... will be of inestimable value to the Authority ..."(p.11)[47], and that "... Bureau trained Authority engineers were able to assume greater responsibility for engineering design ..." (p.20)[48], thus allowing other more senior engineers to concentrate on more difficult construction related work. Thus the value of the training, both formal and informal, lay in its immediacy and ability to be repeated at any time.

At the least obvious level, and the most difficult to specify, are the benefits gained by those who were exposed to the USBR's operating methods either directly or indirectly, including trainees, contractors and their employees, and Authority personnel, who as a result performed their work in a different and more effective manner. Mention has already been made of some of the construction contractors, however others which should be included are Electric Power Transmission (EPT) Pty Ltd., Standard Telephones and Cables Pty Ltd, Boving and Co Ltd., Clyde Engineering Co. Pty Ltd, Carrier Air Conditioning Ltd, Mining and General Engineering Ltd, O'Donnell
Just as it is very difficult to trace staff of these organisations who have gone to other newer construction and contracting companies and taken their knowledge and skills with them, so too it is difficult to trace the whereabouts or present job areas and responsibilities of all those who worked on the Scheme and who were in all probability affected by the USRB practices or personnel in one way or another. Some technical staff, including engineers who studied with the USRB in Denver have remained with the Authority to this day. These include Messrs F. Millner (Operations Planning Engineer), R. McKay (Main Plant Engineer), K. Montague (Senior Executive Engineer Corporate Services), J. McLean (Investigations Engineer), R. Dawson (Executive Engineer Civil), G. Shelton (Technical Services Engineer), R. Goddard (Communications Systems Engineer), R. Warwick (Manager Maintenance Planning), and F. Crook (Branch Head, Mechanical Engineering Maintenance).

Others who served with the Authority and trained with the USRB accepted positions with the Snowy Mountains Engineering Corporation. These include Messrs D. Price (Managing Director), T. Lewis, R. Cameron and R. Neal (General Managers Operations), J. Hilton (General Manager Engineering), R. Paton (General Manager Business Development), N. Carter (Manager Malaysia), M. Kotowicz (Manager Indonesia) and special consultants J. Cooke (large dams and hydro-electric projects), A. Frost (electrical and mechanical engineering), and J. Hunter (civil engineering projects).

By virtue of their contact with USRB staff and working procedures, and the experience they gained on the Scheme, Authority staff as early as 1957 began to provide formal assistance to other Government bodies in Australia. These included a diamond drilling team to assist in field
investigations for the Cotter Dam (ACT), as well as advice and hydraulic model experiments, and collection of hydrolographic data for the Humpty Doo Rice Project in the Northern Territory.[50] These consulting activities remained and increased over the next fifteen years until with the virtual completion of the Scheme the Australian Government established in 1970 the international consulting organisation, the Snowy Mountains Engineering Corporation, to retain the engineering skills and expertise built up during the time it took to investigate, design and construct the Scheme.

SMEC has utilised this experience in electrical, mechanical and civil engineering aspects of both surface and underground hydro-electric power stations in various parts of the world in schemes ranging from 100 kW capacity to those which incorporate 250 MW generating units. Their experience in the related area of power transmission systems and substations covers all stages from pre-feasibility studies to the final commissioning for systems ranging from 11 kV to 330 kV, and includes expertise in the studies of system stability, surge protection, load flow and voltage variation and transmission line design and route selection. Similarly their multi disciplinary staff enables it to provide a range of services in prefeasibility investigations, feasibility studies, field investigations and laboratory studies, design and preparation of contract documents, contract management and construction supervision, operation and maintenance, and training in the disciplines of river basin studies, regional and rural development studies, dams, roads and bridges, water supply irrigation and flood control, tunnels and underground works, pipelines gates and valves, field investigations, laboratory studies, project management, and power generation and transmission. These services have been carried out in some 45 countries including Afghanistan, Bahrain, Bangladesh, Botswana, China, Fiji, India, Indonesia, Korea, Malaysia, Nepal,
Papua, Phillipines, Saudi Arabia, United States, Vietnam and Yemen. In 1985 the United States engineering magazine Engineering News - Record, ranked SMEC 41st in the top 200 engineering design consultants world wide, based on total fees earned outside home countries.

It can be seen then that not only have a large number of Australians and Australian companies benefited both directly and indirectly from the assistance provided by the USBR but so too have overseas countries by virtue of consulting projects undertaken by the Authority, SMEC, and other Australian companies whose working practices draw on their experiences from the Scheme.

Whilst an analysis of the costs and benefits of the role of the USBR is of interest, so too is an examination of the path by which the technology was transferred to the Authority. At the conceptual level there appear to be three different ways for organisations to transfer new and improved products and methods between countries: through subsidiaries or joint ventures set up with local partners; through licencing or sale of patents, trademarks, and other intellectual property rights; and through machinery and equipment sales or supply of turn-key plant. However, whilst this differentiation appears relatively straight forward it was neither as clear in the 1950's nor as directly applicable to the Scheme as may be suggested, partly because the analysis goes more to private enterprise functions and partly because the Authority and the Bureau appear to have had a special type of relationship which does not fit any of the three paths. Issues of direct investment, global strategy, effects of balance of payments, and licencing agreements which tend to be of concern to host governments today when acquiring technology from private enterprise, did not appear to overly concern the
Federal Government and the Authority during the construction phase of the Scheme. The two peak Governments dealt directly with each other as did the two Authority's concerned, to the specific exclusion of private enterprise organisations. There did not appear to be a profit motive involved in the assistance provided by the Bureau, with overheads and other administrative charges having been kept to a minimal level. However, it could be speculated that the interests of the American Government were somewhat broader than the provision of assistance with regard to the construction of the Scheme. This indication of their preparedness to assist with such a venture especially when coupled with their role in the war effort and Australia's increased reliance on them, could be seen as preparation for a longer term influence both within Australia and the larger regional area.

It is questionable whether this type of arrangement for a major construction scheme could work in today's climate given the changes in funding, Governmental expectations for return on investment, the funding of research and development, and the closer relationships between aid provided to under-developed countries and their economic and political success, not to mention multi national corporations and the profit motive. Even if an arrangement such as that between the Authority and the Bureau were able to be put, it is doubtful whether the costs would be the same.

In introducing technology and technology transfer it was stated that change is often a cumulative process which requires considerable human effort and commitment of resources. This was certainly true of the technology transfer between the USBR and the SMA. Whilst the basic engineering concepts remained the same the designs, plans and specifications all under-
went change as the Scheme gradually evolved, as did the methods for achieving its development particularly in the areas of work organisation. The Bureau, experienced in the provision of assistance to developing countries, insisted on the commitment by the Authority of dedicated human resources to assist in the transfer process. These included Australian liaison officers, co-ordination engineers, and frequent visits to America which in turn were reciprocated by Bureau personnel who visited the Authority to check development, in addition of course to the provision of dedicated engineering advisors based on site in Australia. Other resources in terms of money, machinery and materials were all committed by the Authority and the Commonwealth Government on a progressive basis.

The people involved in the development and construction of the Scheme, from the Governments of the U.S.A. and Australia, the staff of the USBR and the SMA, staff of the contractors, and the day labour forces all combined to ensure the successful completion of the Scheme. Some of them were formal agents of change and transfer whilst others were informal agents, some played major and long term roles whilst others were involved only briefly. Irrespective of their formal or informal status their contributions through planning, discussions, suggestions, directions, exhortations, delegation, criticism, organisation and control, all assisted the appropriate contextual fit and the requisite levels of communication. For some to be able to identify and be identified with a national project which was continuously publicised as the greatest engineering feat in Australia was sufficient motivation. For others the simple fact that they were employed and earning reasonable wages was sufficient motivation to endure the physical hardships associated with construction of the Scheme. This motivation
to succeed permeated the workforce and greatly assisted the organisation's receptivity to new techniques. The fact that the Authority was created with the single purpose of first constructing and then operating the Scheme ensured that the full attention of the staff was directed towards, and receptive to, the appropriate technologies.

How then does one measure and report on whether the transfer of Technology from America to Australia, but more specifically from the USBR to the Snowy Mountains Scheme, was successful?

It would appear obvious that the USBR possessed, by virtue of the experience and expertise of its personnel and in its accumulated documentation information and skills required by the Authority to commence the planning and development of the Scheme. This planning and development was to not only draw on the stock of knowledge "in situ" in Denver but also later on from its advisors located in Australia. The speed with which the initial parts of the Scheme could be commenced was important for achievement of the Government's aims both for the Scheme and at the broader level in terms of national reconstruction and one suspects for political survival. For these latter reasons it is clear that the Government and the Scheme as the receiver of the Technology not only wanted the information but was prepared to initiate and support obtaining it. This is exemplified by the capital borrowings and financial outlay of the Government, by the establishment of an appropriate infrastructure, and by support for the continued development of its personnel. The mutual confidence which existed between the two National Governments and at Bureau and Authority level was created and enhanced by the interchange of staff in the very early days of the Scheme, e.g. visits by Mr (later Commissioner) Dexheimer
of the USBR to Australia, and Associate Commissioner Lang of the Authority to the USBR. Prior contact with USBR staff had been made by Hudson when with the Metropolitan Water Sewage & Drainage Board on the Warragamba Dam project and of course through knowledge of the experience of USBR project work. The Authority had shown its bona fides also by written contact with the US Government (through the Australian Embassy in Washington) and with consultants to the USBR who commented favourably on the job to be done and no doubt the public relations value of adding such a scheme to the Bureau's list of credits. The fact that the Australian Government was prepared to pay both for initial design assistance and for the training of some of its engineers at a time when there was an excess capacity within the Bureau would also no doubt have appealed.

It should be obvious therefore that the Australian Government had a direct involvement in both the financial and human resource allocation issues, as well as enhancing the climate in which the technology transfer was to take place by a variety of measures including legislation, public relations and education. The Snowy Mountains Hydro-electric Power Act 1949, the Authority's enabling legislation gave it enormous power over the gazetted area including the power to take land on lease, take easements over land, sell or otherwise dispose of land vested in the Authority, (Section 18), the power to enter land (Section 19), the power to enter and occupy land (Section 20), the power to raise or lower the level, impound, divert or use the waters of a lake, river or stream (Section 21). The most significant power though was that the Authority was able "to do anything incidental to its powers". (Section 18(j)) [54] The flooding and rebuilding of the township of Adaminaby is but one example of this power.
Perhaps not surprisingly, there was no great community comment about the floodings or damage to the environment, due in no small part to the huge public relations campaign mounted by both the Authority and the Commonwealth Government. This included newspaper, radio and later television progress reports, the production of vignettes and news reel items for movie theatres, and handouts, brochures, books and other publications on the Scheme mostly printed within its own printery. In addition to these, the Authority commissioned films of the Scheme's development and conducted an extensive system of public relations tours by both coach and car convoy. At one stage the Authority had a public relations staff in excess of 45, and over the construction days entertained an impressive list of Royal and other dignitaries and official visitors. Whilst this direct involvement is not of itself a measure of the success of the transfer of technology, it is a very good indicator of the preparedness of the Government and the Authority to ensure the foundations and support for continuing development were present. Thus in setting these foundations the Government created not only a new organisation that did not suffer from the normal resistance to change, especially to technology from an extra mural source, [55] but also a motivation and an attitude to succeed both within that organisation and the community at large. Notwithstanding its critics, the majority of Australians today acknowledge the Scheme as one of this nation's greatest achievements.

Available literature suggests that if the enunciated needs are met, the defined requirements fulfilled, stated goals attained, performance specifications met, in short that the required job is done, then the transfer of technology has been successful. Based on this criteria, the completion of the Upper Tumut works and flowing from that the construction of the
whole Scheme, was an outstanding success. From the design of the broad
development parameters and the completion of operational and contract
drawings, to the contract supervision the Bureau's involvement conformed
with, and in the face of lack of defined requirements as often occurred,
specified them, for the Authority. The stated goals, initially assistance
with Modified Scheme C, but which as we have seen varied significantly
over the period of the following ten years, were clearly met, at a cost,
and within the time frames allocated. The fact that both participants
spoke the same language and possessed similar notions of education, class,
and national interest also assisted in the smooth flow of scientific knowledge,
techniques and information.

There is no intention in this document to downgrade or in any way
diminish the exceptional achievement of those individuals who were and
are collectively responsible for the conception, planning, construction,
operation and maintenance of the Snowy Mountains Scheme. Rather it
is the intention to acknowledge the significant role played by the personnel
of the United States Bureau of Reclamation who manifestly assisted and
materially advanced the development of the Upper Tumut works of the
Scheme and who at the same time were responsible for the successful
transfer of relevant technology in the form of knowledge, techniques and
information, to the Authority and in the longer term to Australia and overseas
countries with which it has consulted. This successful transfer of technology
was a joint venture between the Australian Government and the Snowy
Mountains Authority and the United States Government and the Bureau
of Reclamation, and was achieved because of direct legislation and financial
assistance, indirect encouragement and support, training and development,
both in America and Australia, technical assistance from the Bureau,
creation of a suitable infrastructure, and technical advice from Bureau staff in Australia.

A construction project, the magnitude of which had never before been attempted in Australia brought to successful completion under budget and under time, and which satisfied the design parameters must by definition be a success. The Snowy Mountains Scheme was and is a success, a success due in no small part to the successful transfer of technology from the United States Bureau of Reclamation.
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