BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD 1985/8

GAS STORAGE IN AUSTRALIA

by

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BMR RECORD 1985/8

G A S S T O R A G E I N A U S T R A L I A

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Figures on Plate 1

SUMMARY

In Australia there are currently three operating natural gas storage projects (Table 1, Plate 1):

1. a liquid natural gas (LNG) plant at Dandenong, Victoria,

2. a sub-surface sales gas storage in the Cooper Basin, South Australia (S.A.).

3. a sub-surface ethane storage in the Cooper Basin, S.A.,

In addition, current available information indicates there are at least seven domestic feasibility studies being undertaken (Table 1, Plate 1) which may lead to the development of gas storage:

1. in a disused coal mine (N.S.W.)

2. in two depleted gas fields Western Australia, and in one depleted gas-producing coal shaft, N.S.W.

3. in aquifers : in the Sydney Basin N.S.W.
   in St Vincent Basin S.A.
   Underlying Darwin region N.T.

STATE	PROJECT	GAS STORAGE FACILITY	STATUS	TYPE OF GAS STORED/OR MAY BE STORED	GAS STORAGE OPERATOR(S) OR GAS STORAGE INVESTIGATOR(S)	GAS STORAGE CAPACITY ($\times 10^9 m^3$)	CURRENT VOLUME OF GAS STORED ($\times 10^9 m^3$)	ORIGIN OF GAS STORED/OR TO BE STORED	STORED GAS USED TO SUPPLY/ OR WILL BE USED TO SUPPLY
VICTORIA	DANDENONG	LIQUID NATURAL GAS PLANT	OPERATIONAL SINCE 1980	SALES GAS	COMMONWEALTH INDUSTRIAL GASES LTD, & GAS & FUEL CORPORATION, VIC.	0.002 (12×10^3 tonnes of LNG)	0.002 (12×10^3 tonnes of LNG)	GIPPSLAND BASIN	MELBOURNE AND ENVIRONS
SOUTH AUSTRALIA	MOOMBA 'A'	PARTIALLY GAS DEPLETED FORMATION	OPERATIONAL SINCE 1980	SALES GAS	SANTOS LTD	N/A	0.325	COOPER BASIN	ADELAIDE AND SYDNEY
SOUTH AUSTRALIA	MOOMBA 'B'	PARTIALLY GAS DEPLETED FORMATION	OPERATIONAL SINCE MAY '84	ETHANE	SANTOS LTD	N/A	0.064	COOPER BASIN	PETROCHEMICAL PLANTS
SOUTH AUSTRALIA	ST VINCENT BASIN	AQUIFERS	FEASIBILITY STUDIES IN PROGRESS	SALES GAS	SOUTH AUSTRALIA DEPARTMENT OF MINERALS AND ENERGY			COOPER BASIN	ADELAIDE
WESTERN AUSTRALIA	DONGARA	SOON-TO-BE DEPLETED GAS FIELD		SALES GAS	STATE ENERGY COMMISSION OF WESTERN AUSTRALIA	11.270		NORTH WEST SHELF	PERTH AND ENVIRONS
WESTERN AUSTRALIA	WOODADA	GAS FIELD		SALES GAS	STATE ENERGY COMMISSION OF WESTERN AUSTRALIA	0.68		NORTH WEST SHELF	PERTH AND ENVIRONS
NEW SOUTH WALES	BURWOOD	DISUSED COAL MINE		SALES GAS	AUSTRALIAN GAS LIGHT COMPANY	0.040		COOPER BASIN	NEWCASTLE SYDNEY AND WOLLONGONG
NEW SOUTH WALES	BALMAIN	DEPLETED GAS PRODUCING COAL SHAFT/WELLS		SALES GAS	AUSTRALIAN GAS LIGHT COMPANY			COOPER BASIN	SYDNEY
NEW SOUTH WALES	SYDNEY BASIN	AQUIFERS		SALES GAS	AUSTRALIAN GAS LIGHT COMPANY	21.300		COOPER BASIN	NEW SOUTH WALES
NORTHERN TERRITORY	DARWIN	AQUIFERS		SALES GAS	NORTHERN TERRITORY DEPARTMENT OF MINERALS			AMADEUS BASIN	DARWIN

TABLE 1: SUMMARY OF AUSTRALIAN OPERATING AND POTENTIAL GAS STORAGES.

INTRODUCTION

This Record summarises the current knowledge of the Australian developments in surface and sub-surface storage of natural gas. It covers in some detail the operating projects; those under feasibility studies; and discusses in general terms the concepts of the developments considered.

The purpose of the summary is to give factual information regarding these developments and to give assistance in:

- planning of new gas storage facilities,

- formulation of policies for a possible national gas storage program.

Data used in compilation of this summary were obtained by the Bureau of Mineral Resources, Geology and Geophysics (BMR) from:

- State Mines Departments and their agencies,

- petroleum exploration companies,

- gas distributing companies,

- BMR's research and assessment.

GAS STORAGE

General Statement

Because natural gas is used mainly for industrial and household heating its consumption rate is subject to considerable seasonal, weekly, and daily variation. Seasonal demand variations are due mainly to the need for domestic heating in winter, the weekly demand pattern is due to the industrial weekend shut down, and daily demand variations are due to household, and to a lesser extent industrial, demand peaks,. A pipeline large enough to cope with the peaks of a highly variable demand would be unnecessarily expensive; a pipeline of a certain size can be economically justified only if it operates at or near capacity throughout the year.

For a natural gas distributor the following are among the means available to meet or control demand patterns:

. development of gas storage near the points of use;

. duplication of the pipeline;

. restriction of consumption by means of complex contract arrangements;

. variation of price structure in relation to demand.

Storage of gas near the final usage point offers possibly the most efficient means of balancing pipeline energy supplies with a multiplicity of widely fluctuating market requirements as well as providing security of supply. Gas may be injected into storage when market requirements fall below available gas flow in the pipeline. It is withdrawn from storage when market demand exceeds available supplies from other sources.

Storage Techniques

The main techniques used for storage of gas are:

- Depleted gas and/or oil fields,

- Aquifers

- Salt cavities,

- Abandoned coal mines,

- Liquid natural gas (LNG) tanks.

The storage of natural gas in depleted gas and/or oil fields developed as a sub-discipline of gas technology. The developments in storing gas in aquifers have, however, raised gas storage technology to the status of a special discipline.

The first attempt to store gas underground was performed in Welland County , Ontario (Canada), in 1915, by re-injecting gas into a depleted field. Since that time, numerous storages have been developed, first in the USA then in Europe, and from 1980 also in Australia.

In USA at the end of 1983, there were over 420 gas storage pools (380 in the depleted gas and/or oil fields; 40 in aquifers). In France the first underground storage was put into service at Beynes, near Paris in 1956. At the present time, France has 13 storage facilities : 11 in aquifers and 2 in salt cavities.

The technique of storing gas in salt cavities is simple: it consists of dissolving the salt with fresh water and draining off the brine from a single well which will then serve for gas injection and withdrawal. Such facilities are used in France, U.S.A., West Germany and Great Britain.

In Great Britain in 1980, the British Gas Corporation developed the first storage of gas in a partially depleted gas field, the Rough Gas Field 20 km off the Yorkshire coast near the city of Hull.

The storage of gas in disused coal mines is a practical proposition and the developmental costs are comparatively low. Storage of gas in abandoned coal mines was successfully developed in Belgium in 1976 where there are currently two such storages operating.

G

The storage of gas in liquid form (liquified natural gas - LNG) is a further method by which gas can be stored reasonably efficiently in relatively small storage systems. In this form 1 cubic metre of LNG is equal to 600 cubic metres of natural gas at atmospheric conditions. A number of such storages are used world wide including one in Australia.

DEVELOPMENTS IN AUSTRALIA

Victoria

A liquid natural gas (LNG) plant at Dandenong, Victoria, (Plate 1, Fig. 1) was completed in early 1980 and is operated jointly by the Commonwealth Industrial Gases Ltd (CIG) and the Gas and Fuel Corporation of Victoria (Gas & Fuel Corp., 1983).

The plant includes the only LNG storage facility in Australia, and is the first installation in the world to integrate an air separation plant with an LNG liquefaction and storage facility. The basic function of the complex is simple: the CIG Cryocentre liquefies natural gas from the Gas and Fuel Corporation (GFC) in quantities sufficient for use by both parties. CIG then uses the extreme cold of part of the LNG as a source of refrigeration to liquify atmospheric gases for its own commercial, medical and industrial use. This concept is unique in the world.

The plant's liquid natural gas storage tank has a capacity of 12 000 tonnes of LNG or the equivalent of $2 \times 10^6 m^3$ of natural gas. The LNG tank is filled with gas from the Gippsland Basin, offshore Victoria, via a spur to the 174 km gas pipeline from the ESSO/BHP Longford gas processing plant.

The volume of LNG stored at the Dandenong plant provides an invaluable back-up supply of natural gas to boost the Gas and Fuel Corporation's in-hand gas capacity and improve the guarantee of security of reticulated supply to urban, regional and industrial Victoria. According to Gas and Fuel Corporation (1983), the storage volume of LNG is sufficient to supply all their domestic consumers for about 2½ days in winter or up to 5 days in summer.

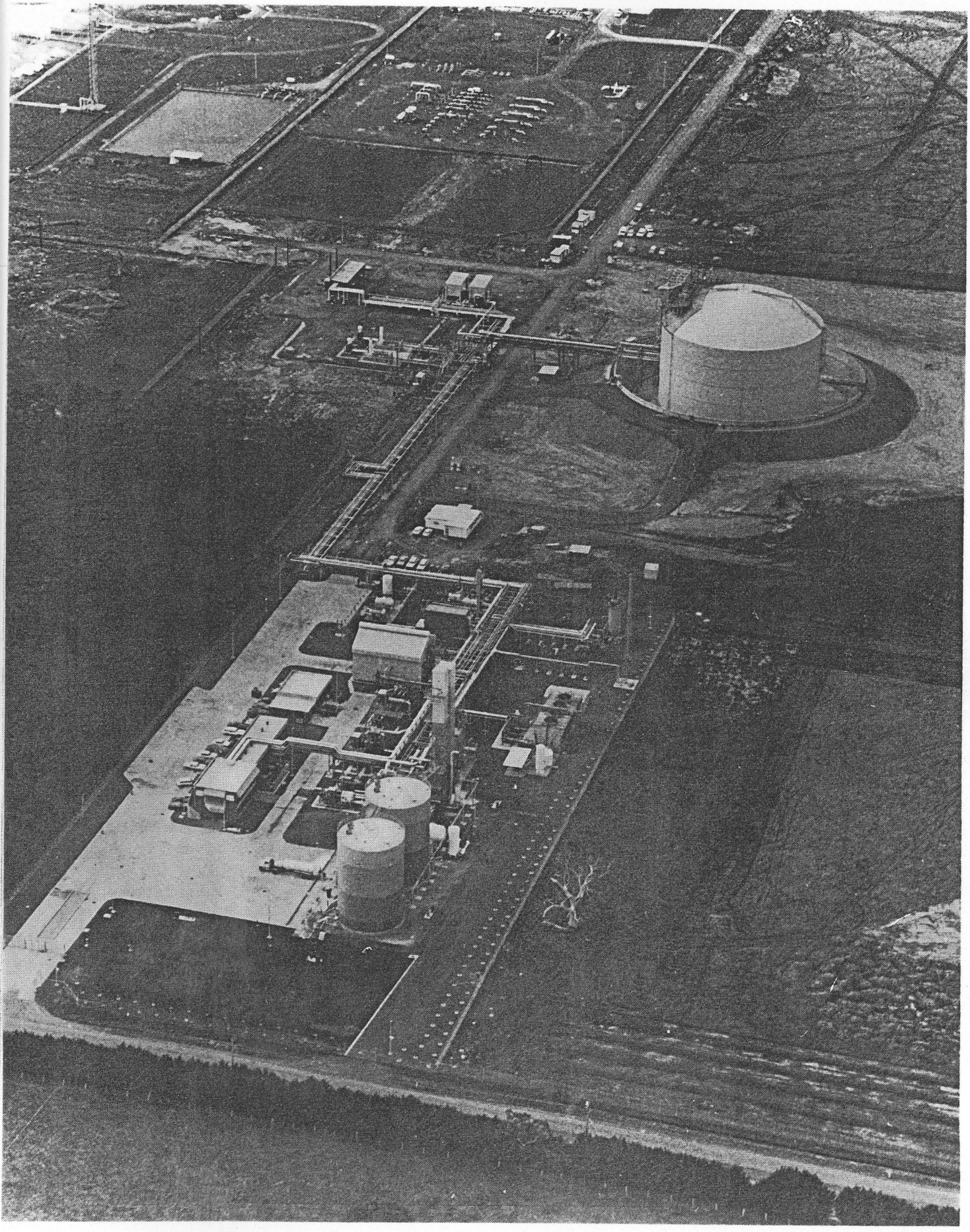

Fig 1. An aerial view of the Liquid Natural Gas Storage plant at Dandenong, Victoria.

South Australia

Sub-surface storage of sales gas and ethane in the Cooper Basin, SA, is being operated by Santos Ltd (Plate 1).

The sales gas storage was developed in early 1980 in partially depleted gas bearing lower Daralingie Beds within the Moomba gas field (Plate 1, Figs 3 & 4). The stored sales gas volume rose initially from 83 x $10^6 m^3$ in January 1982 to 189 x $10^6 m^3$ prior to winter 1982 when a portion of the stored gas was produced to meet peak demands. At the end of 1982 the volume of gas in storage had increased to 285 x $10^6 m^3$. The stored volume at the end of 1984 was 325 x $10^6 m^3$.

The ethane storage was developed over the past three years and became operational during 1984. According to Santos Ltd (1983), the storage utilises the lower Daralingie Beds north of the present sub-surface sales gas storage area. The ethane storage is part of the Cooper Basin producers long range ethane marketability planning related to the establishement of a possible petrochemical plant in South Australia. At the end of 1984, the volume of ethane in storage was 64 x $10^6 m^3$.

Sub-surface storage of natural gas in aquifers underlying an area north of Adelaide has been under investigation since 1978 by the South Australian Department of Mines and Energy (SADME Min. Ind. Quarterly No. 11, Sept., 1978). The study has centred on the Tertiary sedimentary sequence beneath the North Adelaide plains, in the Port Gawler and Brickland Park areas following exploratory drilling and seismic surveys (Fig. 3).

According to the South Australian Department of Mines and Energy, an area of about 5 km^2 would be required to provide storage for some 5.0 x $10^9 m^3$ of gas, which would be equivalent to about two months supply for the Adelaide gas market. Such storage, if established, would provide flexibility for the 782 km long Moomba to Adelaide gas pipeline and would also offer an emergency supply if the pipeline failed.

Western Australia

Sub-surface storage of natural gas has been contemplated by the State Energy Commission (SECWA) since 1979 to assist in meeting peak demands for the Perth, the south-western part of the State, and the Pilbara region gas markets. According to the SECWA (1983), when the Northwest Shelf comes into production and the Dongara field is no longer producing, the State will be dependent for its gas supplies on one offshore gasfield (North Rankin), with a single offshore pipeline and initially, a single production platform.

Therefore a feasibility study to use the Dongara and the Woodada gas fields (Plate 1, Figs 5, 6, 8, & 9) for storage of gas is being conducted coinciding with the development of the Northwest Shelf gas resources and the completion of the 1480 km long gas pipeline from Dampier to Perth. The soon-to-be depleted Dongara gas field located 386 km north of Perth has the capacity of storing up to $11.3 \times 10^9 m^3$ of gas. The second gas storage field under consideration, the Woodada gas field, with a storage capacity of about $0.7 \times 10^9 m^3$, is located 60 km south of the Dongara field. Both fields are connected to the Dongara to Perth gas pepeline.

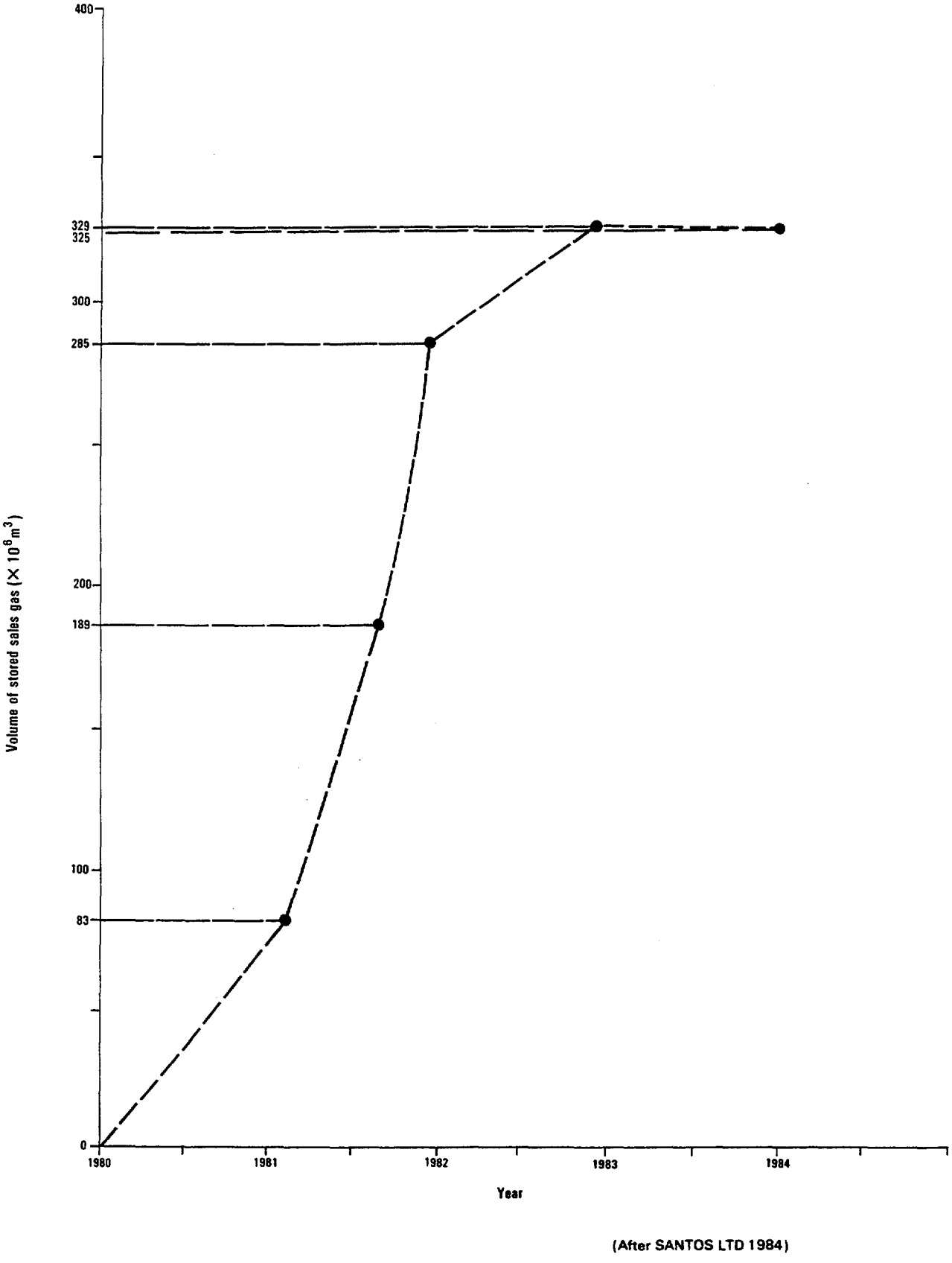

Fig. 2 Cooper Basin. Volumes of sales gas storage, 1980 - 1983.

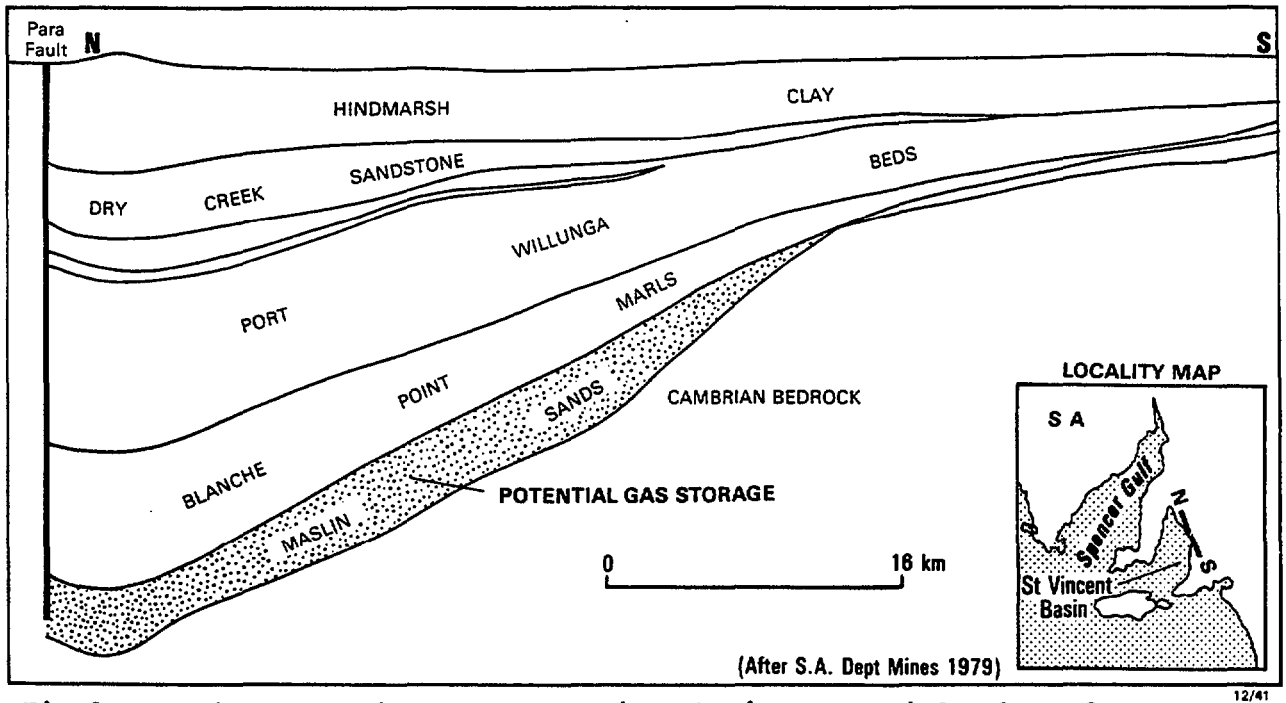

Fig 3. St Vincent Basin coastal section showing potential sub-surface gas storage reservoirs.

New South Wales

The highly populated and industrialised areas of New South Wales are one of the largest markets for natural gas in Australia. Natural gas supplies are brought into these areas by long-distance pipeline (Moomba-Sydney) 1300 km from the Cooper Basin in the northeast corner of South Australia. During July 1982, an explosion in the western part of the Moomba to Sydney pipeline threatened supplies to NSW markets, and highlighted the need for a suitable gas storage facility to supply the major NSW markets during times of emergency or peak demands.

For the past four years, the Australian Gas Light Comapny (AGL), NSW's sole gas supplier, investigated a number of potential gas storage sites in proximity to NSW markets. It conducted feasibility studies to store gas in a disused coal mine, a depleted coal shaft, and in a number of aquifer beds (Plate 1, Figs 10 & 11).

According to AGL, the disused coal mine (Burwood Colliery), located near Newcastle, could store about four to five days' gas requirement (approx. 40 x $10^6 m^3$) for Newcastle, Sydney and Wollongong (Australian Financial Review 30.7.82). Possibilities of storing gas in a depleted gas producing coal shaft (Balmain Shaft) located in central metropolitan Sydney is also being investigated by AGL (pers. comm. Mr T. Davis, AGL, June 1982). Gas produced from the Balmain Shaft was used during World War II as an emergency fuel in motor vehicles. For this purpose, a production rate of 3240 m^3 per week was attained (Mayne et al, 1974).

AGL is also investigating possibilities of storing gas in a number of aquifers within the Sydney Basin (Plate 1, Figs. 10 & 11). These potential storage reservoirs are favourably situated to the NSW gas market and the existing gas pipeline. Their combined storage capacity (Plate 1) would appear to be adequate to serve the NSW market for peak shaving and security of supply. The current NSW daily demand is in the order of 8 x $10^6 m^3$.

Northern Territory

During the past several years the Northern Territory Government has given consideration to marketing natural gas in the Darwin area, particularly of late in connection with electricity generation. Possible sources of this gas have been remote fields in the Bonaparte Gulf and, more recently, fields in the Amadeus Basin.

As all the possible supplies to Darwin are in remote locations, some consideration has been given to possible storage in surface and sub-surface (aquifer) facilities for peak demands. The information available indicates that storage plans are currently at a very superficial level only.

Queensland and Tasmania

No developments in gas storage are known.

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1985/8

PLATE 1

AUSTRALIAN SUB-SURFACE NATURAL GAS STORAGES

(OPERATING AND POTENTIAL)

DEPARTMENT OF RESOURCES AND ENERGY

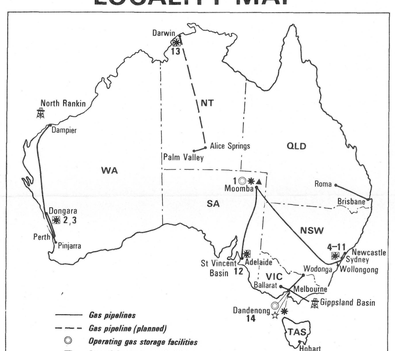
COMPILED BY: S. OZIMIC, and L. PAIN
DRAWN BY S. ANDREWS

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RESOURCE ASSESSMENT DIVISION (PETROLEUM BRANCH)

STATUS	DEVELOPED	FEASIBILITY STUDIES IN PROGRESS											
LOCALITY MAP NUMBER(S)	1	2	3	4	5	6	7	8	9	10	11		
BASIN	COOPER	PERTH		SYDNEY									
FIELD(S)	MOOMBA	DONGARA	WOODADA	STOCKYARD MOUNTAIN	WORON-ORA	DURAL SOUTH	MULGOA	KURRAJONG HEIGHTS		EAST MAITLAND	BALMAIN SHAFT	BURWOOD COLLIERY	
POOL(S)	Daralingie Beds	Caryngina Formation	Caryngina Formation	Nowra Sandstone	Nowra Sandstone	Nowra Sandstone	Nowra Sandstone	Nowra Sandstone	Snapper Point Formation	Muree Sandstone	Illawarra Coal Measures	Newcastle Coal Measures	
		Irwin River Coal Measures		Snapper Point Formation									
RESERVOIR(S) OR SHAFT(S)	Daralingie Beds / Lower Daralingie Beds	Caryngina Fm / Irwin River C M	Caryngina Fm	Nowra Sst / Upper Snapper Pt Fm	Upper Nowra Sst	Nowra Sst	Nowra Sst	Berry Fm/ Nowra Sst	Snapper Pt Fm	Muree Sst	Upper Illawarra C M	Dudley Seam	
TYPE OF GAS STORED OR TO BE STORED	(Sales gas)	(Ethane)											
TYPE OF STORAGE	PARTIALLY DEPLETED GAS BEARING FORMATIONS		TO BE DEPLETED GAS FIELDS		AQUIFERS						DISUSED COAL SHAFTS/MINES		
STORAGE CAPACITY $\times 10^6 m^3$	N/A	N/A	11270	680	130	180	92	8878	922	1546	4730	4994	N/A	?40
CURRENT VOLUME STORED $\times 10^6 m^3$	325	64	NONE										

LOCALITY MAP



OPERATING & POTENTIAL GAS STORAGES

LOCATION MAP REFERENCE NUMBER	AND NAME
1 – MOOMBA	8 – KURRAJONG HEIGHTS
2 – DONGARA	9 – EAST MAITLAND
3 – WOODADA	10 – BALMAIN SHAFT
4 – STOCKYARD MOUNTAIN	11 – BURWOOD COLLIERY
5 – WORONORA	* 12 – ST VINCENT BASIN AREA
6 – DURAL SOUTH	* 13 – DARWIN AREA
7 – MULGOA	14 – DANDENONG LNG PLANT

* Because of insufficient data, the potential sub-surface gas storage zones are not depicted on Plate 1.

Figure 1

COOPER BASIN

MOOMBA
STRUCTURAL CROSS-SECTION A-A'

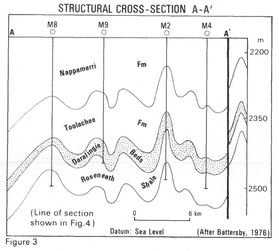


Figure 3

COOPER BASIN
PERMIAN STRATIGRAPHY

AGE	PALYNOLOGICAL STAGES	FORMATIONS	
TRIASSIC		NAPPAMERRI FM	
TATARIAN			
KUNGURIAN–KAZANIAN	UPPER STAGE 5	TOOLACHEE FORMATION	
ARTINSKIAN	U.L. STAGE 5	DARALINGIE BEDS	
	LOWER STAGE 5	ROSENEATH SHALE	
	U.U. ST.4	EPSILON FORMATION	
	UPPER STAGE 4	MURTEREE SHALE	
	LOWER STAGE 4		GIDGEALPA GROUP
	STAGE 3	PATCHA – WARRA FORMATION	
SAKMARIAN–ARTINSKIAN			
SAKMARIAN	STAGE 2	MOORARIE/ TIRRAWARRA FM	
		MERRIMELIA FM	

(After Battersby 1976)

Figure 2

MOOMBA

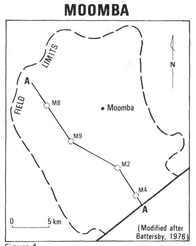


Figure 4

PERTH BASIN

DONGARA
STRUCTURAL CROSS SECTION B–B'

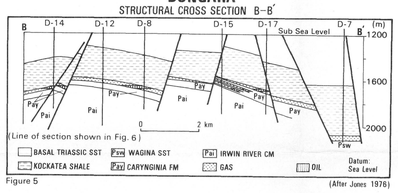


Figure 5

WOODADA
STRUCTURAL CROSS SECTION C–C'

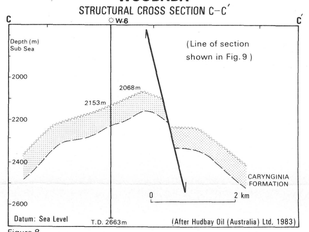


Figure 8

DONGARA
STRUCTURE CONTOURS ON TOP OF BASAL TRIASSIC

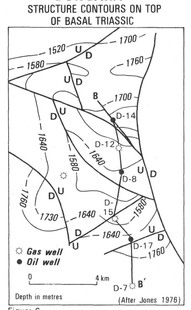


Figure 6

PERTH BASIN
STRATIGRAPHY

SYSTEM	SERIES	FORMATION	LITH
QUATERNARY	PLEISTO–CENE	COASTAL LST	
TERTIARY	PALEOCENE	KINGS PARK SH	
CRETACEOUS	UPPER	GINGIN CHALK	
	LOWER	OSBORNE FM	
		SOUTH PERTH FM	
JURASSIC	UPPER	YARRAGADEE FM	
	MIDDLE	CADDA FM	
	LOWER	COCKLEMUDDY GOLLY FM	
TRIASSIC (R)	UPPER	LESUEUR SST	
	MIDDLE	WOODADA FM	
	LOWER	KOCKATEA SH	
		BASAL 'K' SST	
PERMIAN	UPPER	WAGINA SST	
	LOWER	CARYNGINA FM	
		IRWIN RIVER CM	
		HOLLYWOOD SH	
		NANGETTY FM	
SILURIAN TO ORDOVICIAN OR CAMBRIAN	MIDDLE AND LOWER–UPPER	TUMBLAGOODA SST	
		'BASEMENT'	

(After Jones 1976)

Figure 7

WOODADA
STRUCTURE CONTOURS ON TOP OF CARYNGINA FORMATION

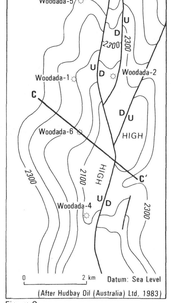


Figure 9

SYDNEY BASIN

LOCATION OF POTENTIAL GAS STORAGE SITES

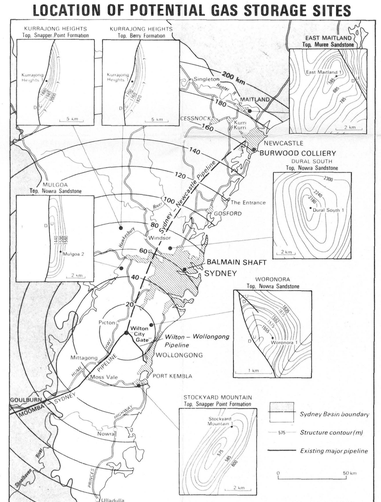


Figure 10

SYDNEY BASIN
ROCK UNIT CORRELATION

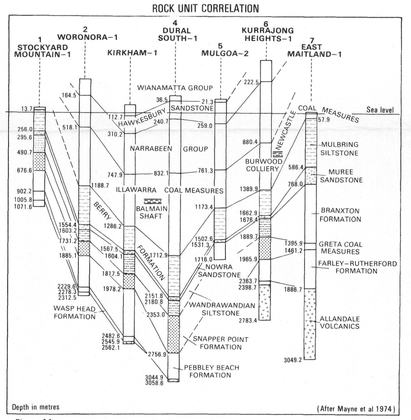


Figure 11

AUSTRALIAN GAS STORAGES SUMMARY SHEET AUST: 1/84