

**BIBLIOGRAPHY ON WATER HANDLING,
ENVIRONMENTAL, AND LAND-USE ASPECTS
OF COALBED METHANE DEVELOPMENT**

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BIBLIOGRAPHY ON WATER HANDLING, ENVIRONMENTAL, AND LAND-USE ASPECTS OF COALBED METHANE DEVELOPMENT

In late October 2001, the British Columbia Ministry of Energy and Mines contracted Western Ecological Services Ltd. to review the literature on water handling, environmental, and land-use aspects of coalbed methane (CBM) development. The review's purpose was to provide background information for the Provincial Steering Committee and Working Group for Coalbed Methane Development – Produced Water Disposal.

The review resulted in several products: a master bibliography of approximately 360 references, alphabetically by senior author, and individually coded by keyword phrases (Attachment 1 of this report); references grouped as sources of information for each of 40 keyword phrases (Attachment 2 of this report); a list of references that could not be keyword coded or annotated because they were unavailable when this review ended on 28 February 2002 (Attachment 3 of this report); a separate report in which 153 key references are annotated (Peterson, E.B.; Peterson, N.M. 2002. *Selected annotated references on water handling, environmental, and land-use aspects of coalbed methane development*. Prepared by Western Ecological Services Ltd., Victoria, for B.C. Ministry of Energy & Mines, Victoria, B.C.); and files that contain the articles, or copies of relevant portions of articles, assembled during the literature search.

1. FEATURES OF THE BIBLIOGRAPHY

The key components of this report are a bibliography of all references in alphabetic order by senior author (Attachment 1), and a separate sorting of references according to their subject matter content (Attachment 2).

1.1 Databases and Information Sources Searched

The electronic databases searched were: AGRICOLA, Applied Science Index, ASFA (Aquatic Sciences and Fisheries Abstracts), Biological Abstracts, GeoRef, GEOSCAN, Conferences, Dissertation Abstracts International, Environmental Knowledgebase, PapersFirst, PubSCIENCE, Science Indexes, Web of Science, WAVES, and WorldCat.

In addition, the catalogues of several university libraries in Canada and the United States were electronically searched including: in Canada, University of Alberta, University of British Columbia, University of Calgary, Dalhousie University, Guelph University, Acadia University, University of Toronto, University of Victoria, University of Waterloo; in the United States, University of Alabama, University of Arizona, University of Colorado, Colorado School of Mines, University of Montana, Montana State University, University of Texas at Austin, University of Wyoming, and University of Utah. Other libraries consulted included: Canadian Institute of Scientific and Technical Information (CISTI); Gas Technology Institute, Chicago; Geological Survey of Canada, Calgary;

Linda Hall Library of Science, Engineering and Technology, Kansas City; and U.S. Library of Congress.

Government department websites of several countries were an additional source of information. For example, Canadian and United States federal department and provincial/state government websites were searched, with particular emphasis on geological and mineral departments, and environmental and natural resource departments. In Canada, these included Environment Canada and Geological Survey of Canada, plus the provincial governments of Alberta, British Columbia, Saskatchewan, and Nova Scotia.

For the United States, website searches included such federal departments as the Bureau of Land Management (and its offices in individual states), Environmental Protection Agency, and the Department of Energy, plus the relevant state government departments of Alaska, Alabama, Colorado, Montana, New Mexico, Oklahoma, Texas, Utah, West Virginia, and Wyoming. Industrial and professional organization sources of information on websites included organizations such as American Association of Petroleum Geologists, Applied Hydrology Associates, Inc., Canadian Petroleum Association, Gas Technology Institute, Petroleum Association of Wyoming, Raven Ridge Resources Incorporated, and Society of Petroleum Engineers.

Some environmental groups have information provided on websites. Examples are the East of Huajatolla Citizens Alliance, Northern Plains Resource Council, Powder River Basin Resource Council, Southern Colorado CURE, and Wyoming Outdoor Council.

As indicated by the significant proportion of references from websites (see Section 3.1), much of the electronic search was by direct access to CBM-related websites, and links or search engines provided on those web pages. Additional information was obtained from CBM-related reports held by V. Levson, B.C. Ministry of Energy and Mines. A few references were obtained by direct contact with CBM investigators in western Canada.

1.2 Structure of the Bibliography

Each reference in the bibliography (Attachment 1) is entered according to five fields: 1. citation; 2. keyword phrases which identify water handling, environmental, or land-use topics contained in the reference; 3. library or website where source document can be obtained or viewed in its entirety; 4. country, province, or state from which the reference originated; and 5. geological formation, coalfield, or basin discussed in the reference, if applicable. For references that are not geographically specific, the term 'general' is used in Fields 4 and 5.

1.3 Keyword Phrases

Each reference in the master bibliography is coded according to the 40-keyword phrases listed in Table 1. In the bibliography (Attachment 1) the appropriate keyword phrases are listed in Field 2 to indicate the subjects referred to in each reference.

TABLE 1**Keyword Phrases for Subject Classification of References in Bibliography,
and Numbers of References Containing Information for Each Keyword Subject**

	Keyword Phrase	Number of References
AB	aquatic biota response	26
AC	aquifer contamination	39
AD	aquifer drawdown or recharge	72
AL	alternative CBM dewatering systems	46
CC	chemical constituents of produced water	126
CE	cumulative environmental effects	37
CH	coalbed hydrology	146
CR	crop responses	16
EL	extensive literature review	15
EX	examples of produced water yields	23
FP	fresh produced water	12
FR	fish responses	23
GM	groundwater monitoring	55
GR	geomorphic responses of receiving streams	14
HP	holding ponds and evaporation	53
HR	hydrologic responses of streams and watershed analyses	47
HU	human consumption of produced water	22
IN	injection of produced water into non-CBM strata	58
IW	irrigation water responses	33
LS	land surface needs for CBM production	66
LU	livestock uses of produced water	29
NA	noise-air quality-aesthetic concerns	21
PE	petroleum field produced water	32
PH	physical characteristics of produced water	13
PI	public interest concerns	37
PP	pre-production planning for handling produced water	53
PR	protection of aquifers and drinking water sources	56
RB	reclamation of damage by brine or surface disturbances	11
RC	reinjection of produced water into coal seams	25
RE	regulations for handling produced water	51
RI	road issues and stream crossings	28
SA	saline produced water	78
SD	surface discharge of produced water	124
SR	soil responses and erosion	58
SU	subsidence in CBM production areas	10
TO	toxicity testing and water quality monitoring	81
TR	treatment of produced water	61
VR	vegetation responses	44
WI	wildlife responses	27
WR	wetland and waterfowl responses	17

There are two keyword phrases, ‘alternative CBM dewatering systems’ and ‘coalbed hydrology’ which captured some articles that have no specific information on above-ground environmental or land-use concerns. This bibliography did not include an exhaustive search of geological aspects of CBM dewatering systems and coalbed hydrology. However, some sample references on coalbed hydrology were included for two reasons. First, because the injection of surfactants or gels to assist hydraulic fracturing of coalbeds could involve compounds of environmental concern if these compounds make contact with ecosystems on the ground surface. Second, the article by Society of Petroleum Engineers (1992) was included because it contains a brief annotated bibliography, and a relatively comprehensive reference list, on the subjects of coal seam permeability and hydraulic fracturing of coalbeds. Although this subject may interest the Ministry of Energy of Mines, it was not assessed in detail in this literature review.

Since there is not a large Canadian literature on CBM development, there was a deliberate choice to include virtually all key British Columbia, Alberta, Nova Scotia, and other Canadian CBM references in the bibliography. Most of these references deal with estimates of the CBM resource but provide little or no information on water handling, environmental, or land-use aspects of CBM development. These Canadian references were arbitrarily coded under ‘coalbed hydrology’ if they could not be coded under other keywords listed in Table 1.

There are two keyword phrases that are not mutually exclusive from the other 38 indexing terms. First, some articles were coded under ‘extensive literature review’ to single out references that contain substantial numbers of citations or provide a literature review of a specific topic. Second, ‘public interest concerns’ was used to identify articles containing viewpoints of citizens and landowners regarding CBM development.

The keyword phrase, ‘petroleum field produced water’, is also not mutually exclusive from many other indexing terms. In general, literature dealing with produced water from petroleum fields was not reviewed in as much detail as references on CBM produced water. However, some sample references on produced water from petroleum field activities were included because alternatives for handling water from that source are similar to alternatives available for CBM produced water. The keyword phrase ‘petroleum field produced water’ allows a user of the bibliography who is interested in only CBM references or only petroleum related articles to segregate these two sources of information.

Keyword phrases that refer to responses are generally in the context of responses to saline or fresh produced water, although for ‘vegetation responses’ it may also be in reference to other kinds of surface disturbances and for ‘wildlife responses’ it may be for other disturbances such as noise.

As much as possible, keyword phrases are neutral and free of negative or positive value judgements. Use of the words ‘contamination’, ‘concerns’, and ‘issues’ in four of the keyword phrases does convey negative connotations about CBM development, but this is balanced by keyword phrases that indicate potential beneficial aspects of CBM produced

water. For example, the most common uses of produced water are indicated by the references indexed under one or more of ‘human consumption of produced water’, ‘irrigation water responses’, ‘livestock uses of produced water’ and, perhaps less directly, under ‘wetland and waterfowl responses’ and ‘wildlife responses’.

Some other potential beneficial uses of produced water, less publicized than the irrigation and livestock water uses, include: dust abatement on roads (Environmental News Network 2001); de-icing of road aggregate storage piles (DeWalle and Galeone 1990); evaporation of saline produced water to yield salt of commercial value (Davidson et al. 1995); creation of wildlife watering areas (Environmental News Network 2001); a variety of constructed wetlands (Davis 1995); and enhancement of fisheries and riparian zones (Environmental News Network 2001; Wyoming Game and Fish Department, n.d.).

Some alternative ways of handling produced water are covered by general keyword phrases such as ‘holding ponds and evaporation’, ‘injection of produced water into non-CBM strata’, ‘re-injection of produced water into coal seams’, and ‘surface discharge of produced water’. There are additional water handling alternatives that are not coded according to more detailed keywords. These alternative handling methods include: remediation treatments in holding ponds or storage tanks, including de-salting processes (Davidson et al. 1995) or concentration of saline produced water in evaporators (Triolo et al. 2000); release of produced water to percolation pits (East of Huajatolla Citizens Alliance 2001); direct application to land with surface evaporation (Davidson et al. 1995) and, in some cases, use of salt-tolerant trees to aid evaporation through transpiration (Hoare 1992); use of produced water as a drilling fluid (Clark and Hemler 1992); conversion of produced water into clean water by reverse osmosis, submerged combustion evaporator, and pulse combustion drier (Triolo et al. 2000). Other more common handling methods include: surface discharge into streams or natural wetlands; release into constructed wetlands; release into irrigation systems; distribution to livestock watering areas; or movement by tank truck for use in road dust abatement or de-icing.

1.4 CBM References Sorted By Keyword Phrases

Using Microsoft ACCESS, the keyword phrases shown in Field 2 of each reference permit articles to be sorted and grouped in the manner shown in Attachment 2. The numbers of references that were considered to be sources of information for each of the 40-keyword phrases are indicated in the right-hand column of Table 1.

2. CRITERIA FOR INCLUSION AND EXCLUSION OF CBM-RELATED TOPICS IN THE BIBLIOGRAPHY

Several arbitrary decisions were required to define the topics to be included for a water handling and environmental overview of CBM operations.

2.1 Key Topics Included in the Literature Search

The keyword phrases listed in Table 1 are the best indication of topics included in the literature review. In addition to these keyword phrases the bibliography includes several references that did not deal specifically with CBM operations but were considered applicable to CBM produced water concerns. For example, *A Handbook of Constructed Wetlands* (Davis 1995) refers to beneficial uses of a variety of wastewater sources that would also be applicable to handling CBM produced water. Other examples include: the Montana article by Bauder (1998), *When is water good enough for livestock?*; suggestions for revegetation of brine-killed sites (Auchmoody and Walters 1988); and identification of sensitive areas (Colorado Oil and Gas Conservation Commission 2001). Similarly, the report by Collerson et al. (1991) describing dewatering of lignite coal deposits that are being mined in the Williston Basin (rather than being drilled for CBM) is included because of its comprehensive literature review of maximum permissible concentrations in freshwater ecosystems for 33 trace elements. That information could be applicable to any operation involving coal dewatering.

The bibliography also contains some examples of general references on injection wells (Groundwater Protection Council, no date; Wiedman 1996) that are not specific to CBM-produced water but could be applicable to handling produced water from any source.

2.2 Examples of Related Topics Not Searched in Detail

Some subjects that may be indirectly related to CBM production were excluded because they were beyond the scope of this review. The main excluded topics were:

- Fugitive emissions of methane from coal seams as a result of coal mining (see related reference by Levelton et al. 1991).
- Methane recovery and utilization from existing or planned coal mines (see related reference by Levelton et al. 1991).
- Natural escape of methane to the surface and its exposure to vegetation and water supplies (see Gorody 2001, as well as U.S. Bureau of Land Management 2001 for example of methane seeps in northern San Juan Basin, Colorado).
- Environmental role of methane as a greenhouse gas, including inadvertent escape of methane to the atmosphere when it is being extracted in CBM operations (see related reference by Miyamoto 2001).
- Use of water injection wells to enhance petroleum production (see related reference by Groundwater Protection Council, no date).

- Possible water quality effects of compounds, such as surfactants or gels, used to assist hydraulic fracturing of coalbeds (see related references by Jeffrey et al. 1989 and U.S. Environmental Protection Agency, Office of Water 2001);
- Microbial enhancement of methane production from coal beds was not reviewed in detail but the bibliography includes an example of an article on this subject (Scott 1999).
- Procedures for handling wastewater associated with coal gasification and liquefaction technologies, a topic that has been reviewed for the Environmental Protection Service, Environment Canada, by Dearborn Environmental Consulting Services (1983).
- Environmental effects of coal mining were not addressed but we assumed that dewatering at a new coal mine would involve produced water concerns similar to those in CBM operations, and for this reason the bibliography contains a few references on dewatering of new mines (see Collerson et al. 1991; Wrench et al. 1992; Coal Industry Advisory Board 1994), and other water quality aspects of coal mining (Clarke 1995).
- Discharge of produced water into marine ecosystems, for which there is substantial international literature (see two texts edited by Ray and Engelhardt 1992 and by Reed and Johnson 1996), was not a specific search objective but the bibliography contains a few references from estuarine or near-shore marine areas (see Neff et al. 1992; D'Unger et al. 1996, Meinhold et al. 1996, and Mulino et al. 1996) because there may be future interest in methane production from the offshore portions of Vancouver Island coalbeds.
- Ownership aspects of CBM development were not reviewed (see Davidson et al. 1995 for numerous cited references on this topic). The bibliography does contain one detailed review of on-lease and off-lease legal issues arising from CBM development in Wyoming (Hand and Smith 2001). The bibliography also includes articles dealing with land surface disturbances associated with CBM production, but legal aspects of use of surface land and ownership of underlying CBM resources were not reviewed.
- Stream-crossing concerns and other environmental aspects of pipelines used for movement of methane or produced water were not specifically searched, although some of the bibliography's references from the Powder River Basin do address overall infrastructure requirements of CBM production – thus some pipeline-related concerns are addressed in some of the references coded under 'land surface needs for CBM production', or under 'road issues and stream crossings'.
- Keyword phrases shown in Table 1 include the term 'examples of produced water yields' which allowed identification of several references that substantiate the large volumes of produced water possible in CBM operations – however, detailed review of produced water yields was not a specific focus of the literature search because water yields are extremely variable between coalfields, within coalfields, and over time as CBM production takes place.

As the list above suggests, the literature search identified many titles, abstracts, and articles in which the subject was considered beyond the scope of the present review. All excluded articles, abstracts, titles and database search results have been retained for

submission to the Ministry of Energy and Mines in case there are Ministry interests in these excluded topics and information sources.

3. OVERVIEW OF BIBLIOGRAPHY CONTENT

The subsections below describe the sources, dates, and geographic origins of the assembled references. The vantage points represented by the references in the bibliography are summarized, and the most comprehensive articles on water handling, environmental, or land-use aspects of CBM development are identified.

3.1 Sources of Assembled References

Excluding reports listed in Attachment 3, the bibliography contains about 360 references. Sources of these references are as follows: agency reports – 28%; conference proceedings – 26%; website articles – 20%; articles from technical and trade journals – 14%; textbooks – 7%; articles from scientific journals – 4%; and theses – less than 1%. Many government agency reports were seen only from postings on websites. In such cases, for purposes of this tally, the source of the reference is listed as an agency report rather than a website article.

3.2 Dates of Assembled References

Approximately 93% of assembled references date from 1990 or later, and a large proportion (52%) of the references are dated 1999, 2000, and 2001. This is partly a result of many of the references deriving from reports posted on websites, but it also indicates a very recent interest in water handling, environmental, and land-use aspects of CBM development. A testament to the rapid appearance of new information on this subject was the presence of new articles in January 2002 on some websites that had previously been searched during the 100-day duration of the literature review.

3.3 Geographic Origins of Assembled References

The greatest amount of information on water handling, environmental, and land-use aspects of CBM development is from Wyoming, Colorado, Alabama, and Montana. The geographic focus of the assembled references is listed in descending order in Table 2. The Table 2 figures for numbers of references are additive to more than 360 because many references provided information for more than one jurisdiction. The bibliography includes references from 12 of the 13 CBM basins recognized in the conterminous United States: Arkoma, Black Warrior, Central Appalachian, Greater Green River, Illinois, Northern Appalachian, Piceance, Powder River, Raton, San Juan, Uinta, and Wind River basins. No references were obtained for environmental aspects of CBM development in the Western Washington Basin. Several references pertain to Alaskan coalfields.

TABLE 2. Geographic origin of information in the master bibliography, excluding the un-coded references listed in Attachment 3.

State, Province, or Country	Number of References in Bibliography
General (not specific to any one jurisdiction)	69
Wyoming	99
Colorado	57
Alabama	44
Montana	34
British Columbia ^a	23
New Mexico	21
Alberta ^a	19
Utah	13
Australia	7
Kansas	5
Pennsylvania	5
Alaska	4
Oklahoma	4
California	3
Canada	3
New Zealand	3
West Virginia	3
China	2
Iowa	2
Kentucky	2
Louisiana	2
Nebraska	2
Nova Scotia	2
Poland	2
Saskatchewan	2
Texas	2
United Kingdom	2
Virginia	2
Other ^b	1

^a There was a decision to include nearly all CBM-related references that originated in British Columbia and Alberta, even if many of them contain little or no water handling, environmental, or land-use information on CBM operations. Such references were coded under the keyword phrase 'coalbed hydrology'.

^b The bibliography contains one reference from each of the following jurisdictions: Arizona, Arkansas, Czechoslovakia, Germany, Illinois, India, Indiana, Manitoba, Maryland, Mississippi, Ohio, Russia, South Africa, and Tennessee.

3.4 Vantage Points Represented by Assembled References

Collectively, the assembled references contain the perspectives, findings, and viewpoints of a broad range of interests with respect to CBM development. The main vantage points are listed below, with a sample representative reference given for each.

- Provincial regulatory agency perspective (Alberta Energy and Utilities Board 1991)
- State regulatory agency perspective (Montana Environmental Quality Council, Coal Bed Methane & Water Policy Subcommittee 2001)
- U.S. federal regulatory agency perspective (U.S. Environmental Protection Agency, Office of Water 2001)
- Provincial research/administrative agency perspective (B.C. Ministry of Energy & Mines 2001)
- State research/administrative agency perspective (Regele and Stark 2000)
- U.S. federal administrative agency perspective (U.S. Bureau of Land Management, Montana 2000)
- Canadian federal research agency perspective (Dawson 1995)
- U.S. federal research agency perspective (Rice and Nuccio 2000)
- CBM developer perspective (Oil and Gas Journal 1999)
- Industry association perspective (Petroleum Association of Wyoming 2001)
- Landowners perspective (East of Huajatolla Citizens Alliance 2001)
- Environmental non-governmental organization perspective (Wyoming Outdoor Council and Powder River Basin Resources Council 2001)
- University extension perspective (Phelps and Bauder 2001)
- Academic-scientific research perspective (McBeth et al. 2001)

The numbers of references representing each of these perspectives have not been tallied. However, perusal of the entries listed in the bibliography indicates that most articles originated from government agencies, conferences involving governmental representatives and CBM researchers, and public interests groups. There is a less abundant literature from the CBM industry for the subjects reviewed here.

3.5 List of Most Comprehensive Articles on Water Handling, Environmental, or Land-Use Aspects of CBM Development

For this relatively large reference list, an interested reader may be unsure where to begin. There are two suggestions. First, the accompanying report prepared for the Ministry of Energy and Mines, *Selected annotated references on water handling, environmental, and land-use aspects of coalbed methane development*, reduces the information sources to 153 references that were considered to be the most informative. Second, the introduction of the annotated references report singles out the following ten references that collectively provide an overview of the range of subjects covered by this literature review:

Rogers 1994 - for general principles and practices of CBM development;
Rice and Nuccio 2000 – for a concise scientific overview of the CBM resource;
Rice, Wanty, Byrer, and Kruger 1995 – for an overview of CBM development;
Lawrence 1993 – for a technical perspective from the CBM industry;
Shuey 1990 – for CBM regulatory and policy approaches;
Waren 1999 – for an agency approach to hydrologic monitoring;
O’Neil 1994 – for water quality monitoring of discharged CBM water;
Triolo, Ogbe, and Lawal 2000 – for CBM operations in cold regions;
Zander 1999 – for scoping of CBM environmental impact assessments;
East of Huajatolla Citizens Alliance 2001 – for public interest CBM concerns.

Two very comprehensive environmental impact statement (EIS) reports became available on websites just as this review was closed. In draft form, these two EIS reports can be viewed on the following websites.

U.S. Bureau of Land Management, Montana Board of Oil and Gas Conservation, and Montana Department of Environmental Quality. 2002. Montana statewide draft oil and gas environmental impact statement and amendment of the Powder River and Billings resource management plans. Various paging. <http://www.deq.state.mt.us/coalbedmethane/DraftEIS/DraftPublicEIS.pdf>.

U.S. Bureau of Land Management, Wyoming. 2002. Draft environmental impact statement and draft planning amendment for the Powder River Basin oil and gas project. BLM, Buffalo Field Office, WY. WY-070-02-065. Various paging. <http://www.prb-eis.org/>

These draft EIS reports are highlighted because they are not listed in the alphabetical lists of authors in Attachments 1 and 2. Two precursors of the draft Montana EIS are listed in the bibliography under ALL [Arthur Langhus Lane] Consulting and CH2M Hill (2001), one report dealing with water resource aspects and one with soil aspects of CBM development.

Some other examples of informative summaries of water handling and other environmental aspects of CBM development include:

- ALL [Arthur Langhus Layne] Consulting and CH2M Hill (2001) – Two technical reports by these consultants reviewed water resource and soils topics in support of a Montana CBM-related environmental impact statement.
- Davidson et al. (1995) – This review by International Energy Agency Coal Research, London, is a concise but very informative review of environmental aspects of CBM development, including treatment and disposal of produced water. The extensive literature review is international in scope, although most of the citations are based on United States CBM experience.
- Flores et al. (2001) – This Powder River Basin report is a comprehensive list of environmental concerns associated with CBM operations, without detailed discussion.

- Horn (1990) – An appendix to this review of environmental management for CBM operations contains suggestions and guidelines for a CBM best management practices plan.
- O’Neil et al. (1993) – This report from the Geological Survey of Alabama provides a comprehensive review of water quality monitoring, aquatic toxicity testing, and treatment technologies for CBM produced water.
- Regele and Stark (2000) – This Montana Department of Environmental Quality report, although brief, identifies most of the biological and land-use issues associated with CBM production.
- Schneider (2001) – Two articles by this author provide information on the choice of re-injecting produced water into coalbeds *versus* injection of produced water into non-CBM formations.
- Warrance and Bauder (2001) – Two university extension reports by these authors provide an informative overview of reinjection of CBM produced water in relation to protection of groundwater resources.
- Wyoming Outdoor Council and Powder River Basin Resource Council (2001) – This well illustrated compilation by non-governmental organizations is a comprehensive listing of environmental and land-use concerns in Wyoming’s CBM developments from the public interest perspective.

As the examples highlighted above indicate, most of the information on environmental and land-use aspects of CBM development is based on experience in the United States. The literature search revealed very few environment-related references from overseas CBM operations, and compared to the United States there are not many Canadian reports on environmental aspects of CBM development.

4. OTHER PRODUCTS OF THIS REVIEW

As indicated above, this bibliography is complemented by a separate volume of selected annotated references that should be useful to readers who do not have access to library holdings of key references in this bibliography.

For references listed in this bibliography, except those in Attachment 3, the entire article has been copied if it is short. For longer articles, only the portions of the text dealing with water handling, environmental, or land-use topics, along with the article’s table of contents and references cited, have been copied. The files of copied articles are deposited with V.M. Levson, Ministry of Energy and Mines, Victoria.