SECTION VI
DISCUSSION AND CONCLUSIONS

It is recognized that estimating future water availability for synfuel development is a difficult and complex task often involving inadequate data, imperfect demand forecasting procedures, unforeseen political and legal factors, and time and budget limitations. Furthermore, it is recognized that it is always easy to criticize the work of others. The following conclusions and recommendations are not intended as criticism for the sake of criticism, but rather they are offered to help prepare the way for more effective assessments of water availability in the future--not only for synfuel development, but water resources management in general. They are also offered to highlight for the decisionmaker the difficulties and uncertainties underlying predictions regarding water availability.

The objective of the study has been to: (1) describe and analyze the hydrologic, institutional, economic, and legal issues involved in assessing and interpreting estimates of water availability for synfuels development, and (2) evaluate the adequacy of currently used estimates of water availabi1ity as a basis for energy planning. In accordance with this objective, the conclusions and recommendations are divided into several categories.

GENERAL

The reports and studies reviewed vary significantly in effectiveness for estimating water availability for synfuel development.

The site specific studies reviewed (i.e. "Water Assessment Report for the Great Plains Gasification Project, Mercer County, North Dakota" and the "Water Assessment for Monongahela Synfuel Plant") present adequate water availability assessments in accordance with the relatively limited objectives of the reports. However, the Great Plains 13(c) report was generally precluded from use by decision-makers because the study was done after the decisions had been made.

Reports such as the Section 13(a) assessments of water availability in the Upper Colorado and Upper Missouri Basins (Colorado Department of Natural Resources, 1979 and U.S Water Resources Council, 1980) are generally appropriate, within their limitations, for broad policy decisions by Governors, state agencies, Congress, and energy companies. These reports provide a general indication of water availability and the level of synfuel development that could be supported--if various uncertainties were resolved in specific ways (e.g. the State of Montana continues its reservation of 5.5 million acre-feet on the Yellowstone River). Therefore, the reports are useful to decision-makers concerned with broad policy decisions in the immediate future before the plethora of uncertainties in the long-term (perhaps after 10-12 years in the future) makes meaningful analysis difficult and speculative. Such reports, however, are generally inappropriate for use in specific synfuel facility siting decisions because they: a) present only aggregated flow data for major basins, b) contain only limited, general cost data concerning alternative supplies, and c) lack necessary data concerning reservoir operating policies, minimum flow requirements at specific points, and so forth.

The Upper Colorado River Basin 13(a) Assessment, “The Availability of Water for Oil Shale and Coal Gasification Development in the Upper Colorado River Basin,” represents the most useful and complete report reviewed. It: (1) provides a relatively good discussion of alternative sources of supply; (2) generally gives an adequate discussion of the legal, economic, and institutional constraints, and the uncertainty surrounding these constraints; and (3) provides ranges of future estimated demand and depletions while being candid about the uncertainty in these forecasts.

The various reports reviewed for the Upper Mississippi Basin were concerned with water availability for synthetic fuel development mainly in the State of Illinois because of the concentration of coal resources in that state. These reports (especially “Coal and Water Resources for Coal Conversion in Illinois”) should be useful to a wide range of decision-makers concerned with “real world” programmatic and policy decisions, and, in some cases, siting decisions for specific facilities. These reports avoid many complexities by concentrating on current water availability and not attempting to forecast detailed energy development scenarios for the Upper Mississippi Basin. In addition, they present the most complete set of cost data for water resource development of any report reviewed.

The Section 13(a) water assessment for the Upper Missouri Basin, "Synthetic Fuel Development for the Upper Missouri River Basin," will probably not be as useful a report to decision-makers concerned with water availability in the Upper Missouri Basin as the comparable report will be to decision=makers in the Upper Colorado. The main conclusion of the Upper Missouri report is that major storage and conveyance systems must be constructed before the extensive water demands of the projected synfuel industry can be met. The report, however, only presents general and schematic information on the location, capacity, costs, and other data of these required facilities. Furthermore, the report includes only limited information about the substantial institutional, legal, political and economic constraints which confront acquisition of necessary water rights and implementation of the required storage and conveyance facilities. Failure to communicate the magnitude of these difficulties and constraints to decision-makers is a major shortcoming of the report, which limits its usefulness. In contrast to the Section 13(a) report for the Upper Missouri River Basin, a non-governmental analysis of water availability for energy development in the Yellowstone Basin by Boris and Krutilla (1980) presents a more detailed and complete analysis of the institutional, legal, political and economic obstacles that confront development of required reservoir storage and conveyance and acquisition of necessary water rights.

The analysis of water availability for energy development in the Ohio Basin is probably the least useful of the reports and studies reviewed. It suffers from the usual difficulties (uncertain forecasts of future demand, lack of data, etc.) but has an additional deficiency in that it assesses water availability on only the mainstem of the Ohio River and ignores the tributaries. This limitation to only the mainstem substantially limits its usefulness to decision-makers for programmatic and policy decisions.

It is likely that the present controversy and uncertainty concerning water availability for synfuel development will continue in the future. Doing additional studies in order to get "better" or more refined estimates of water availability for synfuel development will probably not significantly reduce the controversy surrounding water availability. The reason for this is that many assumptions must be made in aggregating data into a form useful to decision-makers and in forecasting future demand and supply. These assumptions cannot all be explicitly detailed, communicated to decision-makers, and properly used by decision-makers in their own analyses. As a result of the general uncertainty surrounding these assumptions, there will always be potential for controversy over water availability. In other words, a finite limit as to quality probably exists for reports dealing with water availability for synfuel development. The Upper Colorado Section 13(a) Assessment probably approaches this limit.

This is not to say that "improved" analyses of water availability cannot be made; they can and should be completed. The point, however, is that seeking perfection in assessing water availability is an asymptotic process.

Because of the many difficulties and uncertainties inherent in predicting the timing and quantity of future demand by industrial, municipal and agricultural users and the related difficulty in forecasting depletions by these same users, considerable uncertainty exists in forecasts of water availability for synfuel development beyond the present. Reliability of forecasts of water availability for the period beyond 2000 is questionable.

In almost all of the analyses of water availability for synfuel development that were reviewed, the emphasis has been on "predicting" what will happen in a situation where unpredictable political, judicial, and administrative decisions are pending. It would appear that the degree of certainty conveyed in many of these reports is misleading--especially to high level decisionmakers who are unfamiliar with the many assumptions upon which the individual reports are predicated. Rather than focus on “predicting,” it is recommended that the objective of these reports should be to acknowledge the intractable imponderable and to play out the consequences of some of the ways in which the decisions may go. Such analysis should concentrate on evaluating possible tradeoffs that could result.

Therefore, it is suggested that the primary use of the reports and assessments reviewed should be to assess the availability of water for initial development of synfuel industries in the respective river basins and tributaries. “Initial development” includes that group of synfuel plants presently in some phase of planning and which can reasonably be expected to be in operation in the next 10-12 years.

Furthermore, it is suggested that water availability assessments not be predicated on an energy or synfuel development scenario for the river basin. Except for the case of a report prepared specifically for national level decision-makers concerned with whether the United States can meet a national synfuel production goal by a certain date and whether individual regions can make specific contributions to this goal, the specification of a synfuel development scenario for a river basin does nothing except insert more uncertainty and speculation into the report. Instead, the water analyses assessments should concentrate on future water availability (net of all depletions except for synfuel development) and generally allow decision-makers to supply their own synfuel development scenarios. In addition, the assessments could detail the various tradeoffs that could occur if various levels of synfuel development were to occur.

<u>WATER AVAILABILITY FOR SYNFUEL DEVELOPMENT</u>

The purpose of this section is to bring together information presented elsewhere in this report which will allow a reader to obtain quickly an overview of water availability for synfuel development in a specific basin.

Upper Mississippi River Basin

The Upper Mississippi River Basin is that portion of the Mississippi River upstream from the confluence of the Ohio and Mississippi Rivers at Cairo, Illinois. The Upper Mississippi River Basin includes portions of the states of Illinois, Missouri, Iowa, Wisconsin, and Minnesota. Synfuel development will probably be concentrated in Illinois since this is the only state in the basin with major coal resources.

From a regional perspective water supplies for synfuel development in-the Upper Mississippi River Basin are adequate. Localized problems, however, may result depending on the specific site for a synfuel plant. Water supply shortages and negative impacts on water resources are most likely to occur for synfuel sites on tributaries. These shortages and negative impacts can be eliminated or reduced by construction of reservoir storage on tributaries, conjunctive use of ground and surface water or other measures to reduce diversions from unregulated streams during low flow periods.

Ohio/Tennessee River Basin

These two major river basins include portions of Pennsylvania, West Virginia, North Carolina, Ohio, Kentucky, Tennessee, Indiana, Illinois, Maryland, New York, Alabama, and Georgia. Major coal deposits are scattered throughout many states in these basins and significant potential for synfuel development exists.

The water availability situation in the Ohio and Tennessee Basins is comparable to that in the Upper Mississippi. From a regional perspective sufficient water is available for projected synfuel development but localized problems or deficiencies may occur for synfuel plants sited on tributaries. The extent and nature of these deficiencies can only be predicted with site specific studies.

Upper Colorado River Basin

The focus of synfuel development in the Upper Colorado River Basin is on the impending oil shale development activities. Projections for synfuel development in this area range from approximately 1,000,000 barrels a day to more

more than 8,000,000 barrels per day. Much of this development is expected to take place in a three-county area in northwestern Colorado which experiences an annual average precipitation of less than 12 inches and presently has only one town with a population greater than 5,000.

Water is available, and can be made available, in the Colorado River Basin in Colorado to meet oil shale development in the future. The question is not really whether water is available, but rather what the impacts on agriculture and other sectors will be from allocating this water from its present and potential use to synfuel development. For example, approximately 150,000 acre-feet of water storage presently exists in two federal reservoirs on the Western Slope of Colorado which, in part, could be made available for synfuel production. Assuming the consumptive use requirement of a 50,000 bbl/d shale oil plant is approximately 5,700 acre-feet per year, the available stored water in these two federal reservoirs alone could supply a number of unit-sized synfuel plants, more than the number of synfuel plants presently in some state of planning within Colorado. This available stored water could be more efficiently used and stretched further as a source of synfuel water supply when combined with existing junior rights of energy companies. If, however, the projected plants were to rely on water transferred from agricultural use rather than existing available water in federal reservoirs, the impact on the agricultural sector would be much more severe.

The case study of the Upper Colorado River Basin in Colorado herein goes into detail concerning the economic, political, institutional, and legal uncertainties which make it difficult to predict the level of future synfuel development in the upper Colorado River Basin, and the source arid amount of water supply for this projected level of development.

Upper Missouri River Basin

Within the Upper 'Missouri River Basin, synfuel development can be expected to occur primarily in the Yellowstone River Basin and the adjacent coal area. This area encompasses portions of Montana, Wyoming, North Dakota and South Dakota.

In order to provide necessary water for projected synfuel development in this area, major new water storage projects would be necessary because of the significant inter- and intra-year variation of stream flows for all rivers in the basin. Furthermore, the legal, institutional, political and economic issues are of such magnitude in this river basin that they do not allow an unqualified conclusion as to availability of water for synfuel development. In the Yellowstone River Basin and the adjacent coal areas, it is not a matter, as in the Upper Colorado River Basin, of merely what the effects will be of transferring existing water to synfuel development, but rather whether this water will be available at all. Major state reservations of water on the main stem Yellowstone River, Indian reserved rights, and the Yellowstone River Compact all present major uncertainties as to availability of necessary water for synfuel development in this area. Section V herein details the nature and effect of these legal, economic, institutional, and political uncertainties.

PHYSICAL AVAILABILITY

Of the many data-and information bases required for assessing water availability (e.g., future municipal demand projections, future cooling water requirements for coal-fired electric generating stations, etc.), recorded historic streamflow is probably the most accurate and dependable. In the eastern basins, this recorded data set is used more or less directly to assess water availability based on 7-day, 10-year minimum low flows. The use of 7-day, 10-year low flow data for this purpose in eastern basins is desirable since the 7-day, 10-year flow parameter: (1) coincides with many water quality regulations, (2) provides indication of low flow conditions for navigation, and (3) provides a useful estimate of flow in rivers with limited storage.

In the western basins, water availability assessments are based on virgin flow estimates since western state water laws and interstate compacts are predicated on this concept. Virgin flow estimates are based on recorded streamflow data and estimates of depletions. Significant effort is often made to estimate virgin flows, but the resulting data set may be inaccurate because of poor records of diversions, irrigated area, inaccuracy *in* estimating irrigation consumptive use, etc.

Depletion estimates are uncertain because of inadequate records, unrecorded return flows, illegal diversions, and other limitations. Therefore, the principal parameter in western basins on which water availability for synfuel development is based, mean annual virgin flow, incorporates considerable uncertainty. Furthermore, studies assessing water availability in western basins for synfuel development tend to treat mean annual virgin flow estimates as deterministic rather than stochastic variables. These studies do not clearly express the uncertainty and risk (in the statistical sense) that exist in mean annual virgin flow estimates, thereby giving an unwarranted degree of certainty to this data set. For example, some analyses of water availability in the Upper Colorado River Basin treat the estimated mean annual virgin flow as a deterministic, stationary quantity rather than a stochastic variable.

The use of mean annual flow and mean annual virgin flow estimates for assessing water availability is acceptable for rivers and tributaries where adequate storage exists to control the river. However, where little or no storage exists, or will exist in the near future, some estimate of low flows is needed. This could be weekly, monthly or 7-day, 10-year minimum low flow data depending on local hydrologic conditions and data availability. Without this low flow data, decision-makers will have little idea of how proposed synfuel water demands will affect instream uses: fish and wildlife habitat, run-of-the-river hydropower generation, recreation, and water quality. Low flow data is especially important to assess the cumulative effect of all present and proposed depletions as well as the statistical persistence inherent in the hydrologic record.

Groundwater quantity and quality data are inadequate in all of the basin analyses. Some reports more or less ignore this potential water supply source for energy development because of insufficient quantitative data. Individual energy companies may have adequate groundwater data to assist in specific siting decisions, but this data may be unobtainable or do not exist on a regional scale for governmental decision-makers or entities concerned with state or regional water resources management. Use of groundwater for supplying synfuel development could, in some instances, reduce streamflow depletions, especially during low flow periods. Planned conjunctive use of ground and surface waters could result in more efficient use of the surface water resources; i.e., more synfuel plants could be sited in a basin with less impact on the water resource if conjunctive use is employed. However, because adequate groundwater data are not available to regional or state decision-makers, this opportunity may be lost.

ECONOMIC FACTORS

Data concerning costs of developing necessary water resources for supplying synfuel plants were generally inadequate in all reports reviewed with the exception of "Coal and Water Resources for Coal Conversion in Illinois" (Smith and Stall 1, 1975) and Water Rights and Energy Development in the Yellowstone River Basin - An Integrated Analysis, (Boris and Krutilla, 1980). An effort was made in both these reports to present representative and dependable cost data. There are several reasons for the general inadequacy of available cost data.

First, dependable cost data are difficult to collect. No central collection of, for example, reservoir construction cost data exists; data must be collected from a number of individual sources. Second, cost data are site or project specific, and generalization is often risky and inaccurate. Third, developing or obtaining comparable cost data may be impossible. For example, obtaining data on selling prices of irrigation water rights often results in a set of individual prices for widely different commodities. One selling price; may be for a senior irrigation right while another will be for a junior right requiring construction of storage. Several examples of this variation are presented in the Upper Colorado River Basin section herein.

Within limits, cost data may not be very important to energy companies for selecting a water supply for synfuel development since cost of water is generally minor with respect to total capital and operating costs for a proposed synfuel plant.

Cost of water, however, is one determiner of the nature and extent of tradeoffs that will occur as a result of supplying water for synfuel development. Cost data, therefore, should be important to regional and state decisionmakers for: (1) evaluating alternatives for water users displaced by synfuel development and (2) determining the total estimated costs of water resources infrastructure (reservoirs, pipelines, etc.) necessary to support various levels of synfuel development. For example, in the U.S. Water Resources Council's Section 13(a) Assessment of water availability in the Upper Missouri River Basin, it was indicated that major storage and conveyance systems must be developed if the forecast levels of synfuel development were to take place and that the cost of this water resources infrastructure would be an estimated $0.5 to $1 billion dollars. More detailed cost data were not presented. Such aggregated data are not very useful since they do not indicate proposed sources and amounts of funding, cost of specific major projects, and other matters. Without such information it is difficult to evaluate the likelihood that this water resource infrastructure will or should be built. Without such an evaluation, it is difficult to assess water availability for synfuel development with any certainty.

Economic factors are, without question, important in determining the source of water supply for a particular synfuel development. As discussed throughout Sections II-V herein, there are many factors and constraints besides economics, which ultimately determine the source of supply, depletion, and impact on the water resource of a synfuel development. The succeeding section summarizes some of these factors and constraints which may force energy companies to go to more remote or expensive sources for necessary water supplies.

LEGAL, INSTITUTIONAL, AND POLITICAL FACTORS

Perhaps the most difficult requirement in assessing water availability for synfuel development is estimating the effects of legal, institutional and political factors on water availability.

Future judicial decisions, compact interpretations, implementation of certain compact provisions, administrative decisions on marketing federal reservoir storage, resolution of Federal and Indian reserved rights, reservation of water by states, and uncertainties in riparian law, can all have a profound effect on water availability for synfuel development. Communicating the quantitative effects of these possibilities in a water availability assessment is a large task. This task is complicated by the fact that not only must the possible effects be indicated and analyzed, but also some effort should be made to estimate the likelihood of occurrence.

For example, no interstate compact exists between Colorado and Utah for the White River, a tributary of the Upper Colorado River. Seventy-five percent of synfuel development in the Upper Colorado Basin is forecast to take place in the White River Basin (Colorado Department of Natural Resources, 1979). A White River compact could, therefore, be a major determinant in water availability for synfuel development in the White River Basin. Tracing out the quantitative effects on water availability of such a future compact is a difficult but necessary task in assessing water availability.

In general, the reports and assessments reviewed contain highly variable analyses of the quantitative effects of future legal, institutional and political constraints. Probably the best example is the Boris and Krutilla (1980) study which presents detailed and quantitative analyses of a number of legal, institutional and political factors affecting water availability for the Yellowstone Basin.

Political, legal and institutional factors affecting water availability are generally less numerous, and less complex, in the eastern basins than in the western basins. Complex local situations may exist but, in general, the political, legal, and institutional factors affecting water availability for synfuel development are less involved in eastern basins. The probable reasons for this are: (1) less competition for water in the eastern basins, (2) the relative simplicity of riparian water law for surface water, (3) the general lack of, or relatively simple, groundwater regulatory law in eastern states and (4) the difference in hydrologic regimes. As a result, forecasts of future water availability for synfuel development may be somewhat less involved because of the reduced complexity of political, legal and institutional factors.

The relative simplicity of riparian water law and riparian-based groundwater law can, however, result in significant uncertainty concerning future water availability because of lack of protection given users against upstream diversion or pumping adjacent to their lands. In contrast, water law in western states can be a barrier to implementation of water supply alternatives. For example, western state water law is an obstacle to implementation of measures to increase irrigation efficiency since the Appropriation Doctrine does not generally allow a user to retain a right to salvaged water. These measures could, in turn, provide the water saved to synfuel development.

In all the basins reviewed, existing federal reservoir storage can be a significant source of water supply for synfuel development. However, uncertainty over marketing policies and contract terms and bureaucratic and legal delays reduces the potential of this source of supply for synfuel development. This is unfortunate, since these reservoirs are already in place and additional construction would not be necessary.

Uncertainty resulting from legal, institutional, judicial and political factors causes energy companies to be conservative in their water supply planning and acquire redundant supplies in order to be assured of an adequate future-water supply. The delays and uncertainties inherent in acquiring water rights, obtaining reservoir storage, or otherwise initially securing a water supply also tend to cause energy companies to obtain redundant water supplies. Because of this redundancy, future consumptive use may be less than expected.

PROJECTION AND FORECASTING PROCEDURES

Estimating water availability for synfuel development requires a number of projections and forecasts. These range from estimating future population levels and municipal and industrial water demand for specific areas of river basins to projecting the effects of future legal and institutional mechanisms on water availability. This collection of projections and forecasts must be combined in order to estimate the availability of water for synfuel development. Assessments of water availability for synfuel development are generally developed by aggregating existing forecasts of water demand and use in the various river basins. These existing forecasts are of highly variable quality and sophistication.

Lack of effective mechanisms for water resources planning in many basins which are experiencing, or will experience, synfuel development is a serious limitation in producing dependable forecasts and projections of future water availability for synfuel development. Consider the example in Section III herein of the difference in data availability between West Virginia and Pennsylvania for the Monongahela River. The lack of a consistent data base between these two states makes forecasting various effects of synfuel development difficult or impossible. Furthermore, the compilation of data for various political jurisdictions (e.g., states) which do not correspond to hydrologic boundaries and the use of this data for forecasting purposes also creates bias, error, or uncertainty in the resulting forecasts. States and other political entities generally are optimistic when predicting future water demands and assume significant growth in water use by the industrial, agricultural, and municipal sectors. The total future water use for a basin must be equivalent to the sum of the parts. Reconciling the projections and forecasts of the individual entities so that the total is reasonable is a major job for which there may not be a responsible entity. A major effort was made in the Second National Assessment of the Nation's Water Resources (U.S. W. R. C., 1978) to reconcile the “state futures” with the “national futures,” i.e., to insure that the whole was equivalent to the sum of the parts. In many river basins, no planning entity exists that can produce uniform, consistent and dependable forecasts or predictions of parameters affecting water availability for synfuel development.

Another deficiency in currently available forecasts for water availability for synfuel development is that these forecasts may have good procedures for estimating future water demand, but that procedures for translating these demands into surface or groundwater depletions may be surrounded with uncertainty for a number of legal, political and institutional reasons. Consider, for example, the Colorado River Basin in Colorado. A number of estimates of future synfuel development for various sub-basins of the basin can and are being made. Reasonable forecasts of water demand for synfuel development and associated municipal demand can be made. However, demand estimates are not usually the final desired forecast or estimate. The final desired forecast involves those parameters characterizing expected quality and quantity depletions of the ground and surface waters of the region. Translating demand forecasts into depletion estimates requires numerous assumptions concerning future institutional, political and economic parameters. For example, on the Sangamon River in the Upper Mississippi Basin (see Section II herein) estimating future demand for cooling water for the Clinton Nuclear Power Plant is a reasonably straight-forward exercise. (Estimating future water demand for a synthetic fuel plant at the same location would be a comparable task.) Translating this demand forecast into estimates of future depletions in the Sangamon, Illinois and Mississippi Rivers, however, is far more difficult and requires numerous assumptions about future economic and institutional conditions. For example, economics will largely determine if the source of supply is groundwater, direct diversion from the river, or tributary storage. Each of these sources will have very different effects on depletions during low flow periods on the Sangamon, Illinois and Mississippi Rivers.

Therefore, with respect to the adequacy of forecasting and projection procedures, the following conclusions can be made:

1) Forecasts of water availability for synfuel development in a particular river basin depend on aggregation of a number of individual forecasts in a number of sectors: agriculture, manufacturing, energy, municipal, etc. There may be significant variation in the quality and dependability of the forecasts in these various sectors.

2) Forecasts of water availability for synfuel development require combining data and forecasts for water demand from various political entities (e.g. states) in the river basin. There may be significant variation in the quality and quantity of data and forecasts from these political entities which may seriously limit the ability to predict or forecast impacts of synfuel development on the water resources of a region, river basin, or sub-basin. The lack of an efficient and effective planning entity in most river basins indicates this situation will probably not change in the immediate future.

3) Many forecasting procedures associated with assessing water availability for synfuel development are designed to ultimately produce estimates of water demand. Translating these demand forecasts into estimates of quality and quantity depletions of ground and surface waters involves, perhaps, even more uncertainty than the original demand forecasts. This uncertainty results from potential future legal, political, economic and institutional constraints that may develop.

4) Assessments of water availability for a period of 10 to 12 years into the future should be reasonably good since we generally have some indication for this period concerning what plants may be built, what water supply sources will be used," specific plant sites, etc. However, after this 10-12 year period, the legal, political, economic and institutional uncertainties become much greater and the dependability of the forecasts diminish.

ALTERNATIVES

For all basins studied, the principal sources of water supply considered in the reports for synfuel development were: (1) direct diversion from rivers, (2) reservoir storage, or (3) acquisition of agricultural water rights. However, numerous other potential sources exist including: (1) development of groundwater, (2) conjunctive use of ground and surface water, (3) weather modification, (4) improvements in efficiency of agricultural and municipal use (and subsequent use of water "saved" by synfuel industry), (4) change to more water efficient processes in synfuel production, and (5) watershed management to increase discharge. Detailed discussion of these alternatives for synfuel development water is presented elsewhere and will not be repeated here (Office of Technology Assessment, 1980; U.S. Environmental Protection Agency, 1979).

Some of these alternatives appear to offer attractive sources of water supply for the synfuel industry but their practical implementation is constrained by political, legal and institutional barriers. For example, the Colorado River Basin assessment report (Colorado Department of Natural Resources, 1979) discusses the possibility of employing municipal water conservation measures to reduce exports from the Colorado Basin for municipal use (primarily to the Denver metropolitan area) and using this saved water for synfuel development water supply. Numerous studies throughout the United States have demonstrated the cost-effectiveness and feasibility of reducing municipal demands by 10 to 30 percent. Therefore, this alternative would appear, at first impression, to offer an economically efficient and environmentally desirable water supply for synfuel development in the Upper Colorado River Basin. However, as discussed in the Upper Colorado River Basin section herein, substantial political, legal and institutional barriers -confront implementation of this alternative. These constraints are not discussed in the Section 13(a) study for the Upper Colorado.

This situation is typical of the treatment of other alternatives in the Upper Colorado River Basin Section 13(a) assessment as well as in other reports reviewed. In general, alternatives for synfuel water supply, other than the usual reservoir storage and direct diversion, are detailed with some limited discussion, but without analysis of the legal, political, economic and institutional constraints that limit their consideration and implementation in the real world.

BASIN COMPARISON

The objectives of the study have been to analyze the various factors involved in assessing water availability for synfuels development in four major river basins and evaluate the adequacy of currently used estimates of water availability as a basis for energy planning in these basins. With respect to the objectives of this study, there are considerable differences among the four basins studied.

In the eastern basins, the Ohio/Tennessee and the Upper Mississippi, significantly less competition exists for water than in the western basins. As indicated in the Ohio/Tennessee and Upper Mississippi discussions herein, the expected future total depletions, both for the mainstems and tributaries, are far less than in the Upper Colorado and Upper Missouri River Basins. In general, for the Ohio/Tennessee and the Upper Mississippi, adequate water supply exists for presently proposed and future synfuel development on the mainstems and larger tributaries without major new reservoir storage. Instream requirements and local shortages may limit availability in some areas and arrangements for alternative water supply during drought periods, (e.g., groundwater, or side channel and tributary reservoirs) may be necessary. This water can be made available with a minimum number of potential legal, institutional, and political obstacles.

The relative' absence of legal, institutional and political obstacles to water-availability in the eastern basins primarily results from the relative simplicity of eastern riparian water law, lack of interstate compacts, no major Federal or Indian reserved rights questions, and the few institutions concerned with water resources. While this environment of simpler law may make water available more easily, it does not provide the assurance of continued supply that the appropriation doctrine water law of most western states provides. Riparian water law in states such as Illinois, Indiana, Tennessee and other eastern and Midwestern states gives a groundwater or surface water user little protection against depletion by others. This is in contrast to the western basins where appropriation based law and the more complex institutional and political setting will probably provide more obstacles to obtaining a water right; but once the right is obtained, the user has a more certain supply. Therefore, while the legal, institutional, and political environment of water availability is far less complex in the eastern basins than in the western basins, this relative simplicity and ambiguity are responsible for considerable uncertainty concerning future water availability.

For the eastern basins, the absence of interstate compacts, the lack of the general accounting requirements of western appropriation law, and the relatively few institutions concerned with water resources result in no entity having responsibility for regularly assessing the total cumulative depletions or diversions for a particular stream or aquifer. The lack of such an entity creates additional uncertainty concerning future water availability due to disparities among states in water quality and quantity data and estimates of depletion due to future development.

For the western basins, the Upper Missouri and the Upper Colorado, the opposite of much of the above is the case. The complexities of western states' water laws, the numerous interstate compacts, and Federal and Indian reserved rights create obstacles and uncertainty concerning future availability of water for synfuels development. However, these same factors also create a relative certainty of supply once that supply is obtained. In addition, these same factors have resulted in a form of regional and basin accounting of depletions.

Similarities also exist among the basins. In all basins, groundwater data is marginal or inadequate for purposes of assessing its potential as a source of supply for synfuel development. Forecasting demand for all water uses is a very uncertain process everywhere. As a result, assessments of water availability for the future (e.g., beyond 2000) are uncertain at best and must be interpreted very carefully. In general, the reports reviewed are mainly useful for assessing water availability at present for initial development of synfuel industries within the next 1O-I2 years.