17--SECONDARY ENVIRONMENTAL IMPACTS FROM URBANIZATION

By Barry L. Walton and Edward M. Dickson

A. Sources of Secondary Environmental Impacts

The environmental effects of the operation and construction of synthetic liquid fuel plants can be considered to be "primary" or "direct" impacts. The environmental consequences that arise from the attendant urbanization and behavior of residents can be considered to be "secondary" or "indirect" impacts. These secondary effects can contribute significantly to the overall environmental change that is likely to occur in a predominantly rural region that undergoes substantial growth at a fairly rapid pace. Sources of secondary impacts derive from municipal services (fresh water, production of waste water and solid waste), land use (construction of dwellings, roads, and utility corridors; effect on water run-off patterns), habitation (automotive air pollution, energy utilities, animal mortality), and recreation/leisure activities (use of parklands, vandalism, alteration of habitats). This chapter is primarily concerned with these secondary effects as they apply to the coal and oil shale regions of the West. Some of these effects can be quantified using scaling factors for readily predicted changes, and others can only be projected in a general way, based on empirical evidence from past occurrences.

B. Urban Growth: Coal and Oil Shale Regions of the West

Urban areas in Wyoming, Montana, North Dakota, and Colorado occupy a very small fraction of the total land area. For example, Gillette,

in Wyoming's Powder River Basin, occupies only abour 10,000 acres of the over 3 million acres of Campbell County. Towns in these states are widely dispersed (50 to 100 miles apart).

Urban growth on the open grasslands of Montana, Wyoming, and North Dakota is characterized by sprawling communities with small populations. Urban development in the oil shale country of Colorado, which is characterized by a broken landscape of cliffs, river valleys, and plateaus,[1] would be restricted to the broad-bottomed river valleys, the only land suitable for town-making.

Nearly all of the towns in the coal regions of Montana, Wyoming, and North Dakota, and in the oil shale regions of Colorado have small populations. Gillette, Wyoming (1975 population of 11,000), and Rangeley, Colorado (1970 population of 2150),[2] typify their regions. Population growth from the construction and operation of a 100,000-B/D (16,000-m^3/D) coal liquefaction plant would add an estimated 2400 primary jobs to employment (see Chapter 6) in coal mining, while a 100,000-B/D oil shale complex would add 1700 jobholders in oil shale country. The 2400 jobholders, their families, and the associated service personnel and their families would likely locate in the one or two towns close to the liquefaction facility and the coal mines.

C. Quantifiable Impacts

1. Scaling Factors

Tables 17-1 and 17-2 provide some of the important scaling factors for urban living applied to predicted urban growth in the coal and oil shale regions of the West. The data in Table 17-3 are a compilation of automotive emissions scaling factors for various levels of control anticipated for the future. However, recent postponements in the

Table 17-1

SCALING FACTORS FOR URBAN LIVING

Item	Unit*	Quantity
Fresh water consumption		
National average	Gal/capita day	150
Domestic 40%		
Commercial 18%		
Industrial 24%		
Public uses 18%		
Colorado		170
Wyoming		200
Montana		190
Waste water production		
National average	Gal/capita day	120
Colorado		140
Wyoming		160
Montana		150
Solid waste production		
National average	Lbs/capita day	1400
Residential and commercial electric power consumption	1000 kWh/capita	5.2
Private automobiles		
National average	Cars/capita	0.48
Colorado		0.55
Wyoming		0.51
Montana		0.49
Distance traveled per passenger automobile	Miles/car-year	10,000
Land requirements for dwelling units	Acres/person	0.065
Streets and roads (municipal and rural)		
National average	Mileage/capita	1.8×10^{-2}
Colorado		3.6×10^{-2}
Wyoming		1.2×10^{-1}
Montana		1.1×10^{-1}
Acreage or municipal and rural roads	Acres/mile	12

*Conversion factors: 1 gal = $3.79 \times 10^{-3} m^3$; 1 mi = 1.61 km; 1 acre = $4.05 \times 10^{3} m^2$.

Table 17-2

WATER RUNOFF COEFFICIENT "C" AND
RAINFALL IN WYOMING AND COLORADO
(Fraction of Rainfall Flowing into Rivers and Streams)

Undisturbed land		
Eastern Wyoming*	0.07-0.09	
Piceance Basin†	0.04-0.08	
Disturbed land		
Suburban land‡	0.25-0.40	
Light industrial‡	0.50-0.80	
Gravel roadways§	0.15-0.30	
Rainfall		
Gillette/eastern Wyoming		
Average annual*	11-15 (27-38)	in./yr (cm/yr)
Peak daily**	2.8 (7.1)	in./yr (cm/yr)
Piceance Basin Colorado		
Average annual†	12-24 (30-61)	in./yr (cm/yr)
Peak daily**	2.8 (7.1)	in./yr (cm/yr)

*Average annual runoff of 1 in./yr (Reference 3) with annual rainfall of 11 to 15 in. (Reference 4).
†Average annual runoff of 1 in./yr (Reference 3) with annual rainfall of 12 to 24 in. (References 1, 5).
‡Reference 6.
§Reference 7.
**Reference 8, assuming the same peak daily rainfall for Piceance Basin.

Table 17-3

AVERAGE EMISSION FACTORS FOR HIGHWAY VEHICLES BASED ON NATIONWIDE STATISTICS

	Carbon* Monoxide		Hydrocarbons				Nitrogen‡ Oxides		Particulates				Sulfur	
			Exhaust†		Crankcase and Evaporation		(NO_x as NO_2)		Exhaust		Tire Wear		Oxides (SO_2)	
Year	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km
1970	78	48	7.8	4.8	3.9	2.4	5.3	3.3	0.38	0.24	0.20	0.12	0.20	0.12
1975	50	31	5.0	3.1	1.5	0.93	5.0	3.1	0.38	0.24	0.20	0.12	0.20	0.12
1980	23	14	2.4	1.5	0.53	0.33	3.1	1.9	0.38	0.24	0.20	0.12	0.20	0.12
1990	12	7.5	1.3	0.81	0.38	0.24	1.8	1.1	0.38	0.24	0.20	0.12	0.20	0.12
2000§	3.4	2.1	0.41	0.25	0.38	0.24	0.4	0.25	0.38	0.24	0.20	0.12	0.20	0.12

*1975 standards - 3.4 g/mi.
1976 standards - 3.4 g/mi.
†1975 standards - 0.41 g/mi.
1976 standards - 0.41 g/mi.
‡1975 standards - 3.9 g/mi.
1976 standards - 0.4 g/mi.
§We assume 1976 standards are met for all vehicles in 2000.

Source: "Compilation of Air Pollutant Emission Factors," 2nd Edition, Supplement 2, U.S. Environmental Protection Agency (April 1973).

imposition of increasingly stringent emissions standards, suggest that the relevant factors applied in any given time frame of this study are uncertain.

The scaling factors given in Tables 17-1 through 17-3 have been used to derive the results shown in Tables 17-4 through 17-7 for the Powder River Basin in Wyoming and the Piceance Basin in Colorado for the maximum credible implementation scenario. The significance of the results given in the tables is amplified from the standpoint of environmental concerns in the following sections of this chapter.

2. Water-Related Impacts

a. Runoff

The paving of streets and the roofing of structures alter the runoff of precipitation because there is less open ground to absorb it. This results in the alteration of stream flows manifested both by an increase in quantity and by a compression in time of the flow*

The runoff Q can be expressed by the simple equation

$$Q = CIA$$

where C is a constant, I is the precipitation rate, and A is the area affected.†

Table 17-2 gives the fractional runoff coefficient for various activities that cover the land surface with water-diverting

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*Less time elapses between the falling of the precipitation and the onset of runoff flow, and the runoff flow ceases quicker after the precipitation ends.

†Q is usually given in ft^3/s, I in in./hr, and A in acres.

Table 17-4

IMPACTS FOR CAMPBELL COUNTY, WYOMING, COAL LIQUEFACTION AND METHANOL PRODUCTION--
MAXIMUM CREDIBLE IMPLEMENTATION SCENARIO

Impact	Impact Scaling Factor		Quantities Derived from MCI and Figure 22-2					Scenario for Year				
	Quantity	Units	1975	1980	1990	2000	Units[§]	1975	1980	1990	2000	Units[§]
Fresh water consumption	200	Gal/day person	17	22	60	110	1000 people	3.4	4.4	12	22	$\times 10^6$ gal/day
Waste water production	160	Gal/day person	17	22	60	110	1000 people	2.7	3.5	9.6	18	10^6 gal/day
Solid waste production	1400	Lbs/person yr	17	22	60	110	1000 people	24	31	84	150	10^6 lbs/yr
Residential and commercial electric power consumption	5.2	1000 kWh/person-yr	17	22	60	110	1000 people	88	110	310	570	10^6 Wh/yr
Land area directly affected by urbanization (cumulative)	0.065	Acres/person	17	22	60	110	1000 people	1100	1400	3900	7200	Acres
Municipal and rural road distance (cumulative)	1.2×10^{-1}	Miles/person	17	22	60	110	1000 people	2000	2600	7200	13,000	Miles
Acres affected by municipal and rural roads (cumulative)	12	Acres/mile	2000	2600	7200	13,000	miles	2.4	3.1	8.6	16	10^4 acres
Increased runoff from urbanization during peak annual periods*	C = 0.16 to 0.33 I = 0.7† A	Dimensionless in./hr† Area	1100	1400	3900	7200	acres	120 to 250	160 to 320	440 to 900	810 to 1700	ft^3/s water‡
Increased runoff from municipal and rural roads during peak annual periods	C = 0.08 to 0.23*		2.4	3.1	8.6	16	10^4 acres	1300 to 3900	1730 to 5000	4800 to 14,000	9000 to 26,000	ft^3/s water

*Runoff, Q = CIA (C = a constant, I = precipitation rate, A = area affected).
†Assumes peak daily rainfall of 2.8 inches occurs in a 4-hr period due to thunderstorm activity.
‡1 ft^3/s = 0.646 $\times 10^6$ gal/day.
§Conversion factors: 1 gal = $3.79 \times 10^{-3} m^3$; 1 acre = $4.05 \times 10^3 m^2$; 1 mi = 1.61 km; 1 in. = 2.54 cm; 1 ft^3 = $2.83 \times 10^{-2} m^3$.

Table 17-5

IMPACTS FOR GARFIELD AND RIO BLANCO COUNTIES, COLORADO, OIL SHALE DEVELOPMENT--
MAXIMUM CREDIBLE IMPLEMENTATION SCENARIO

Impact	Impact Scaling Factor		Quantities Derived from MCI and Figure 22-13					Scenario for Year				
	Quantity	Units	1975	1980	1990	2000	Units‡	1975	1980	1990	2000	Units‡
Fresh water consumption	170	Gal/day person	23	50	220	245	1000 people	3.9	8.5	37	42	10^6 gal/day
Waste water production	140	Gal/day person	23	50	220	245	1000 people	3.2	7.0	31	34	10^6 gal/day
Solid waste production	1400	lbs/person yr	23	50	220	245	1000 people	33	70	310	340	10^6 lbs/yr
Residential and commercial electric power consumption	5.2	1000 kWh/yr person	23	50	220	245	1000 people	120	260	1100	1300	10^6 Wh/yr
Land area directly affected by urbanization (cumulative)	0065	Acres/person	23	50	220	245	1000 people	1500	3300	14,000	16,000	Acres
Municipal and rural road mileage (cumulative)	3.6×10^{-2}	Miles/person	23	50	220	245	1000 people	830	1800	7900	8800	Miles
Acres affected by municipal and rural roads (cumulative)	12	Acres/mile	830	1800	7900	8800	miles	1	2.2	9.5	11	10^4 acres
Increased runoff from urbanization during peak annual periods	C = 0.17-0.36 I = 0.7* A	Dimensionless In./hr† Area	1300	1900	14,000	16,000	acres	180 to 380	390 to 830	1700 to 3500	1900 to 3900	ft^3/s water
Increased runoff from municipal and rural roads during peak annual periods	C = 0.07 to 0.26*		1	2.2	9.5	11	10^4 acres	490 to 1800	1100 to 4000	4700 to 17,000	5400 to 20,000	ft^3/s water

*Runoff, Q = CIA (C = a constant, I = precipitation rate, A = area affected).
†Assumes peak daily rainfall of 2.8 in. occurs in a 4-hr period due to thunderstorm activity.
‡Conversion factors: 1 gal = $3.79 \times 10^{-3} m^3$; 1 acre = $4.05 \times 10^3 m^2$; 1 mi = 1.61 km, 1 in. = 2.54 cm; 1 ft^3 = $2.83 \times 10^{-2} m^3$.

Table 17-6

AUTOMOTIVE POLLUTION IMPACTS FOR CAMPBELL COUNTY, WYOMING, COAL LIQUEFACTION AND METHANOL PRODUCTION--
MAXIMUM CREDIBLE IMPLEMENTATION SCENARIO

Impact	Impact Scaling Factor		Quantities Derived from MCI and Figure 22-2					Scenario for Year				
	Quantity	Units	1975	1980	1990	2000	Units*	1975	1980	1990	2000	Units*
Private automobiles	0.51	Cars/person	17	22	60	110	1000 people	8.7	11	31	56	10^3 cars
Automobile travel	10	1000 miles/car-yr	8.7	11	31	56	10^3 cars	87	110	310	560	10^6 miles/yr
Air pollution from automobiles												
Particulates	Mileage	Use data for the	0.58	0.58	0.58	0.58	g/mi	0.05	0.06	0.18	0.32	10^8 kg/yr
SO_2		appropriate year	0.2	0.2	0.2	0.2	g/mi	0.02	0.02	0.06	0.11	10^6 kg/yr
Hydrocarbons		from Table 17-3	6.5	2.9	1.7	0.8	g/mi	0.57	0.32	0.53	0.45	10^6 kg/yr
NO_x			5.0	3.1	1.8	0.4	g/mi	0.44	0.34	0.56	0.22	10^6 kg/yr
CO			50	23	12	3.4	g/mi	4.4	2.5	3.7	1.9	10^6 kg/yr

*Conversion factors: g/mi = 0.62 g/km; 1 mi = 1.61 km.

Table 17-7

AUTOMOTIVE POLLUTION IMPACTS FOR GARFIELD AND RIO BLANCO COUNTIES, COLORADO, OIL SHALE DEVELOPMENT--MAXIMUM CREDIBLE IMPLEMENTATION SCENARIO

Impact	Impact Scaling Factor		Quantities Derived from MCI and Figure 22-13					Scenario for Year				
	Quantity	Units	1975	1980	1990	2000	Units*	1975	1980	1990	2000	Units*
								0	1	15	20	100,000 B/D
Private automobiles	0.55	Cars/person	23	50	220	245	1000 people	13	28	121	135	10^2 cars
Automobile travel	10	1000 miles/car-yr	13	28	121	135	10^3 cars	130	280	1210	1350	10^6 miles/yr
Air pollution from automobiles												
Particulates	Milcage	Use mileage data for the appropriate year from Table 17-3	0.58	0.58	0.58	0.58	g/mi	0.08	0.16	0.70	0.78	10^6 kg/yr
SO_2			0.2	0.2	0.2	0.2	g/mi	0.03	0.06	0.24	0.27	10^6 kg/yr
Hydrocarbons			6.5	2.9	1.7	0.8	g/mi	0.85	0.81	2.1	1.1	10^6 kg/yr
NO_x			5.0	3.1	1.8	0.4	g/mi	0.65	0.87	2.2	0.54	10^6 kg/yr
CO			50	23	12	3.4	g/mi	6.50	6.4	14	4.6	10^6 kg/yr

*Conversion factors: 1 mi = 1.61 km; 1 g/mi = 0.62 g/km.

materials and undisturbed areas. Urbanization of undisturbed lands could be expected to increase runoff 3 to 5 times that of the undisturbed landscape. Much of this extra water goes into storm drains and sewers. In rural areas, new roads will increase runoff into streams.

Table 17-2 also shows the range of annual rainfall for the two regions. Much of the nonsnow precipitation occurs during thunderstorms, with thunderstorms occurring about 30 days per year in eastern Wyoming and about 40 days per year in western Colorado.[3] We assume a peak daily rainfall of 2.8 in./day (7.1 cm/D) for both regions. Thunderstorms will induce the most damaging runoff.

b. Increased Salinity

It is predicted that the withdrawal of river water for municipal use will increase the concentrations of dissolved salts in the Upper Colorado Basin, which experiences problems with increasing salinity.[9] Each milligram per liter increase in dissolved solids per unit volume (salinity) increases the economic detriment in the lower Colorado Basin at the rate of $230,000 per mg/ℓ increase. For an oil shale industry of 1.5 to 2.0 million B/D, the increase in dissolved solids (mg/ℓ) from the increase in residential water consumption is estimated at 0.6 to 1.0 mg/ℓ, which gives a total annual detriment of $1.2 to 2.3 million per year.

c. Waste Water

Analysis has shown that the cost of a shale- or coal-derived synthetic crude oil is insensitive to the cost of water, consequently, a plant could easily afford to treat urban waste water for use. However, it can be readily calculated that the population induced by an oil shale plant would generate waste water at a rate that would satisfy only about 10 percent of the water requirements of a single

plant. Thus, a population of almost 100,000 people would produce only enough waste water per year to satisfy a single 100,000-B/D (16,000 m^3/D) oil shale plant. Clearly, reuse of residential waste water could at best make only a small contribution to meeting the water needs of an oil shale industry.

3. Air Quality Impact

Table 17-8 compares the automotive air pollution with that from an oil shale plant. As can be readily seen, the automotive air pollution is 1/40 to 1/900 that of the air pollution from the oil shale industry. Thus, the impact on regional air quality derived from the atmospheric dispersion modeling of Chapter 16 will be a good representation of the total effect on air quality in the Piceance Basin.

D. Nonquantifiable Impacts

1. Impact of Increased Land Use

Three major urban land uses will develop around the towns in the coal and oil shale regions: Land use of permanent housing and recreation areas for the operating force of the plant and mines, and for the service personnel and their families. Land use for temporary housing for the construction force for the plant (often temporary housing in trailers evolves into permanent housing in the same trailers). Land use for commercial development, roads, and utility corridors.

All of these land uses disturb rangeland, open space, and watershed adjacent to a town. Unpaved roads and graded lands, highly subject to wind and water erosion, create dust and contribute to topsoil degradation. The sparse groundcover and low rainfall contribute to soil instability in areas of disturbed vegetation.

Table 17-8

AIR POLLUTION FROM AUTOMOBILES AND OIL SHALE PLANTS

Impact	Impact Scaling Factor		Quantities Derived from MCI					Scenario for Year				
	Quantity	Units	1975	1980	1990	2000	Units	1975	1980	1990	2000	Units
Air pollutants from oil shale complex*												
Particulates	103	g/s-100,000 B/D	0	1	15	20	100,000 B/D	0	103	1545	2060	g/s
SO_2	394	g/s-100,000 B/D	0	1	15	20	100,000 B/D	0	394	5910	7880	g/s
Hydrocarbons	76	g/s-100,000 B/D	0	1	15	20	100,000 B/D	0	76	1140	1520	g/s
NO_2	514	g/s-100,000 B/D	0	1	15	20	100,000 B/D	0	514	7710	10,280	g/s
Air pollution from automobiles†												
Particulates								2.5	5.1	22	25	g/s
SO_2								1.0	1.9	7.6	8.6	g/s
Hydrocarbons								27	26	67	35	g/s
NO_x								21	28	70	17	g/s
CO								210	200	440	150	g/s

*Chapter 16.
†From Table 17-7.

2. Water Quality Degradation

The relatively arid areas of the Powder River and the Piceance Basin afford considerable opportunity for water quality degradation. Sparse groundcover in the Powder River Basin, when disturbed by construction activity, leads to erosion and stream siltation following rains. In these areas, which are already short of water for urban use, an increase in water consumption will lead to stream degradation through flow reduction. Urban construction on important underground water recharge can lead to the lowering of water tables. Diversion of rainwater runoff through construction activity or the rechannelling of streamflow can lead to water quality degradation. Road construction on the steep unstable hillsides of the Piceance Basin often leads to landslides, which fill or block streambeds.

Much of the water in the areas under consideration flows in underground aquifers. In the Powder River Basin, these aquifers are unlikely to be affected by construction activities or urban growth except through increased usage for residential or industrial use. In Colorado, many of the recharge areas for aquifers lie at the base of cliffs and in the flat areas along rivers. Some disturbance of underground aquifers in this area is possible.[2]

3. Impact on Recreation Areas

Scaling factors cannot be used to generalize environmental impacts that stem from increased recreational or leisure time activities in an area because the effects of these activities are related to the nature of a given locale and the socioeconomic status of the inhabitants of the settlements involved. Particular to this category of impact are the activities of increased use of public parkland, hunting and fishing, and off- and on-the-road travel.

Growth of population brings heavier use of public parklands. Unless the quantity of park-like land with public access increases along with the population, the existing areas receive more intense use--sometimes exceeding their capacity to recover from wear and tear.

People frequently seek outdoor recreational activity on private lands--sometimes by trespass. As the nation becomes increasingly motorized, leisure activity has more and more involved off-the-road driving with such vehicles as motorcycles, dune buggies, four-wheel-drive jeeps and trucks. Much of this off-the-road operation is destructive to vegetation, disruptive to wildlife, and it creates dust and noise problems. Often, access by these vehicles leads to vandalism of historic sites, archeological resources, and unique features of the environment, not to mention litter, which is a common product of off-the-road travel.

State and federal agencies own nearly 35 percent of the land in the Northern Great Plains Resources Program study area, with these lands forming a virtual patchwork quilt on the land. Many different federal and state agencies control land. The recreational value of the land is most likely to be seriously affected by growth. The biological responsiveness of the land and the biological carrying capacity of the land are most likely to be impacted last. Population growth already impacts several areas; for example Flaming Gorge near Rock Springs, Wyoming; Keyhole State Park in northeastern Wyoming near Gillette and Sheridan, Wyoming; and Custer National Forest near Colstrip. Coal development in Wyoming would likely make Keyhole State Park Wyoming's most heavily used park.[10] The Northern Great Plains area and the Rocky Mountains to the west now contain uncrowded recreation areas. Population growth will impact the quality of recreation by introducing crowding and heavy use of the most accessible recreation areas. Rivers and reservoirs, for example, are prime recreation use areas. With a growing demand for

water by energy companies, surface area reductions in many reservoirs are to be expected. More people will share less water for recreation.

The recreation habits of residents in the Northern Great Plains area differ from those of out-of-state tourists. Tourists tend to frequent the better known national parks and monuments. Those residents who hunt and fish generally use state lands, national forests, and Bureau of Sport Fisheries and Wildlife areas. An increase in the resident population from coal mining and conversion will impact local recreation opportunities most heavily, with city and county parks, state parks close to mining towns, and federal lands close to mining activities the most seriously affected. In Wyoming, the annual influx of visitors to Yellowstone National Park, which totals over 2 million people, dwarfs the 300,000 Wyoming residents. In another part of the state, however, in Natrona, Converse, and Niobrara counties (along the Platte River) over 90 percent of the fishing in 1970 was by residents.[10] The impacts from new residents will overshadow the impacts from tourists in most recreation areas other than national parks and monuments.

4. Impact on Animal Populations

Increased population brings with it increased road mileage and road travel in rural areas. This travel endangers the lives of large and small animals that frequently cross the roads: antelope, squirrels, skunks, deer, rabbits, turtles, snakes and raccoons. Nocturnal animals are especially susceptible. Studies have confirmed that a large cause of death among wild animals is their being struck by vehicles on highways.

Increased numbers of people increase the legal and illegal hunting and fishing pressure on game animals and sport fish. In addition, there is an increase in destruction for destruction's sake--especially of predatory animals, birds of prey, and snakes.

The layout of roads, habitation, and recreational areas can affect animals and plants, in a region differentially. Some species adapt well to human activity and even increase in numbers as domestic vegetation substitutes for native forage, or as the number of predators is lessened. Human habitation harms other animals or birds when home range territories are diminished or transected, or when a unique feature essential to part of their life cycle (e.g., trout spawning beds in streams) is destroyed.

Other subtle factors can also be important to the viability of wildlife habitat. For example, the sage grouse and sharptailed grouse prefer certain sagebrush areas as strutting ground for their mating ritual. In the Powder River Basin development will lead to more power utility lines which in the past have given birds of prey an unnatural but strategic vantage point from which to attack grouse; several grouse colonies have been decimated in the past by this means.[11]

In the Piceance Basin, development will withdraw critical winter range in the river valleys for deer, antelope, and elk in the White River and Colorado River Basins. The availability of winter range determines the size of the herd that can be supported by the available habitat. Destruction of winter range has a far more severe effect on herd size than similar destruction of the more abundant summer range.

E. Summary

There are many indirect environmental consequences of the urbanization that would be induced by coal and oil shale conversion facilities developments. Among those that can be estimated quantitatively are effects on precipitation runoff, waste water production, and air quality impacts from automobiles. We have shown that there is little chance of using urban waste water to satisfy all the needs of an oil shale plant because a single plant needs about 10 times as much water as the

population induced by the plant will produce. We have also shown that the automobile contribution to air pollution will be small compared to the pollution caused by the plants themselves.

Important, but nonquantifiable, impacts include effects on land use patterns, over use and abuse of recreational and rural landscapes, and increased animal mortality from being struck by automobiles.

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18--HEALTH ISSUES IN SYNTHETIC LIQUID FUELS DEVELOPMENT

By Robert V. Steele

A. Introduction

There is little question that synthetic liquid fuels development will produce adverse effects on human health due both to the further emission of pollutants already regulated and the release of yet to be identified toxic, carcinogenic, or other health-impairing agents. However, owing to the lack of concrete data on which to base an analysis, the extent of such effects cannot be predicted quantitatively until some development takes place and the appropriate clinical and epidemiological studies are carried out. All that can be done at this stage is to discuss the health issues that are likely to arise as a synthetic fuels industry develops and to point out the critical areas in which research, planning, and testing will be necessary to forestall or minimize deleterious effects on human health.

B. Effects of Industrial Development in New Areas

To the extent that synthetic fuels development is carried out in areas that currently enjoy low levels of environmental pollution, increased levels of health effects are likely to occur in these areas. The impacted population will consist not only of the current residents of these areas, whose numbers are small in many cases, but also of plant and mine workers and their families who will have migrated to the development sites. Even with moderate levels of growth, the new population associated with development could swamp the current population in many areas after 10 or 15 years, as shown in Chapter 22.

Since the number of cases of impaired health should be proportional to both the ambient concentration of pollutants and the number of people exposed, a "square law" might be proposed to express the health impacts of additional development. The "square law" says that health effects increase roughly as the square of the level of production, since both ambient pollutant concentrations and population exposed are roughly proportional to this quantity. Although it would be difficult to make any quantitative formulation of this "square law," the notion indicates that the level of effects may be higher than would be initially expected due to the remote siting of much of the development.

The most obvious health effects would be those related to increased levels of pollutants for which EPA has set standards, especially air pollutants such as NO_x, SO_2, particulates, oxidants, and so forth. The EPA primary standards for these pollutants are designed to protect human health. EPA secondary standards are designed to protect human welfare by minimizing the effects on plant life, materials, etc. If these ambient air quality standards are rigorously enforced, then few health effects would arise from these sources of pollution. As discussed in Chapter 16, there are many variables, however, that determine ambient concentrations of pollutants, including the relative location of plant sites, weather conditions, secondary pollutant releases due to increased population, and so forth. Control measures may not necessarily be applied until some level of pollution is reached at which health effects begin to appear. Even then, it may take several years before appropriate control measures can be implemented.

Another area where time lags may occur between the onset of health effects and the implementation of control regulations is the emission of compounds specific to the new synthetic fuel processes that have not previously been regulated. Careful advance planning and testing will be required to ensure that the releases of all substances that affect health

are accounted for and quantified so that appropriate regulations can be formulated, if necessary.

C. End Use Impacts

Due to the potential for the widespread use of synthetic liquid fuels in automotive transportation, there is a great potential for impacting the health of large numbers of people. The effects of interest are those that arise from differences in the combustion of synthetic fuels compared with those that arise from the combustion of conventional fuels.

The most pronounced differences in automotive pollutant emissions are in the combustion of methanol or methanol-gasoline blends compared with the combustion of gasoline. Reductions in the emissions of automotive pollutants (NO_x, CO, hydrocarbons, and aldehydes) have been reported for straight methanol fuel[1,2] and methanol/gasoline blends,[3] with the exception that aldehyde emissions are higher than for gasoline. Formaldehyde is a partial oxidation product of methanol and it accounts for most of the aldehyde emissions from methanol combustion. It can act as a respiratory irritant and an allergenic agent. The use of advanced catalytic converters can reduce CO, hydrocarbon, and aldehyde emissions by an order of magnitude for both gasoline and gasoline/methanol combustion.[3] Although differences remain in emissions between the two cases, the levels are so low that the differences are no longer as significant.

A problem in the use of methanol is that it displays acute toxic effects both through vapor inhalation (the maximum allowable exposure is 200 ppm compared with 400 ppm for octane) and through absorption by the skin.[4] It is also acutely toxic when ingested orally.[4] However, this is not likely to be a problem in fuel use, especially if blends are employed. Rather, the routine contact with both vapor (methanol has a vapor pressure of 100 mm of Hg at 20°C compared to 10 mm of Hg for octane) and spilled

liquid poses a significant health hazard to service station attendants and others who frequently handle or are exposed to automotive fuels.

Differences in the emissions from the combustion of fuels refined from shale or coal syncrude and those from combustion of conventional fuel have not been identified. It is likely that the only significant differences would be in the trace elements or unburned hydrocarbon emissions. For example, it is known that upgraded shale oil and coal syncrude contain higher fractions of aromatics than do natural crudes.[5] This aromatic fraction is largely converted to gasoline, and the aromatic content of exhaust gas is apparently proportional to the aromatic content of the gasoline. Therefore, higher emissions of aromatics may occur from the use of synthetic gasoline. It is not known whether or not any of these aromatic compounds will be among those identified as carcinogens. However, it has been reported that carcinogens in raw shale oil are destroyed in the process of hydrotreating (upgrading) to produce synthetic crude oil.[6]

Both coal and oil shale contain toxic trace elements. (See Tables 4-13 and 4-14.) It is likely that many of these will be removed during coal liquefaction and shale oil upgrading. However, analyses of the syncrude products have not been carried out, and there is no indication as yet of the extent to which trace elements will find their way into refined products.

D. Localized and Occupational Health Problems

An important concern in coal and oil shale conversion activities is the possibility of adverse health effects on workers and on local communities. This concern is centered more around the possible release of carcinogens, toxic trace elements, or more exotic pollutants than it is around pollutants whose release is currently regulated and that can be

readily controlled. It is well known that substances derived from coal, such as coal tar, contain carcinogenic compounds. Raw shale oil is also known to contain carcinogens. The toxic trace elements in coal and oil shale are discussed in Chapter 4.

The main questions concerning these and other toxic materials are whether will they be released to the environment, and if so, what will be the quantities involved. It has been reported that a coal liquefaction pilot plant operated by Union Carbide had to be shut down in 1960 because the plant workers developed cancerous lesions on their skins.[7] Some mechanisms of airborne release of cancer-inducing material can be inferred from this report. However, since such reports have not been received from other operations, more would have to be known about the actual operating conditions of the plant to draw any conclusions generally applicable to coal liquefaction.

At one point it was feared that the disposal of large quantities of spent shale would create a cancer hazard due to the presence of carcinogenic compounds such as benzo[a]pyrene in the carbonaceous residue on the spent shale. However, tests carried out for The Oil Shale Company (TOSCO) indicate that the carcinogenic potential of spent shale is low, due to the very small concentrations of benzo[a]pyrene and other polycyclic aromatic hydrocarbons.[8] Raw shale oil has a mild carcinogenic potential, comparable to some intermediate refinery products and fuel oils.[8] Upgraded shale oil has a carcinogenic potential about an order of magnitude less than that of raw shale oil, consistent with the belief that polycyclic aromatics are broken down by hydrogenation. Thus, oil shale and its products do not appear to present a serious cancer hazard. However, safe plant operating procedures should be enforced to prevent the workers from contact with intermediate retorting products, which display a "mild" carcinogenic potential.

The release of other toxic substances should be carefully studied to insure that these materials are not released to work areas or the general environment. The pathways and ultimate fates of many substances, including toxic trace elements, in the conversion process are not well understood. Thus, basic chemical and analytical studies should be carried out to determine the contents of all waste streams from synthetic liquid fuel processes to determine if health hazards might be created by these streams and if abatement procedures may be needed.

Another area of concern is the potential for contamination of local water supplies through runoff from solid waste disposal piles--primarily spent shale and coal ash. Although current plans for coal and oil shale conversion incorporate measures to prevent such contamination, some monitoring of waste disposal practices will help to insure that contamination does not occur accidentally--during flash floods, for example. In addition, there are subtle effects that might go easily unnoticed. Examples are percolation of highly saline water through spent shale piles to underlying aquifers and the disposal of coal ash in mined out areas where aquifers have already been disturbed, which would cause further contamination.

E. Research Needs

A great deal remains to be learned about the health effects of synthetic liquid fuel production and use. The need for research in this area is large, but just as important is the timing with which the research is carried out. To have the greatest effect in moderating human health impacts, the research should be carried out simultaneously with the development of the synthetic fuel technologies.

The following important data are needed:

- Identification of all toxic substances, including carcinogenic, teratogenic, and mutagenic agents, in waste streams.
- The transport of these substances through the environment.
- The fate of these substances in the environment, including mechanisms of degradation and transformation.
- The potential for human health impairment at the concentration levels expected from releases from full-scale plants.

The strong need for the type of data indicated above has prompted a number of government agencies to institute research programs to acquire data on health effects of energy technologies. In particular, EPA has begun a study, to be performed by SRI, concerned with radioactive contaminants associated with new energy technologies including coal liquefaction and oil shale conversion. In addition, the EPA Office of Energy, Minerals, and Industry has established several programs in this area. Other organizations, such as the National Institute of Environmental Health Sciences and the National Institute for Occupational Safety and Health, have held workshops in health aspects of energy conversion. Furthermore, the Biomedical and Environmental Division of the Energy Research and Development Administration (ERDA) will be responsible for carrying out health effects research on ERDA-supported technology programs.

There is, therefore, a reasonable expectation that important health effects data will be obtained on synthetic fuel technologies as they are developed and reach the stages of final commercialization. If thorough research and appropriate measures for control and regulation are carried out, it is possible that health effects of synthetic fuels development may be minimal. To insure this, careful coordination of the research efforts of government agencies and private industry is required, along with thoughtful and timely application of research results.

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19--WATER AVAILABILITY IN THE WESTERN UNITED STATES

By R. Allen Zink

A. Introduction

The production of synthetic liquid fuels from coal and oil shale involves water intensive processes.* For projected synthetic fuel plants in the eastern states, it appears that--on a major watershed basis--the water impact will be small even in the dry months of dry years (see Chapter 20). However, for the oil shale region in Colorado and the coal region of the Northern Great Plains, the situation is more complex. The water problem in the semiarid, energy-rich West is not simply one of getting enough water to satisfy demands, it is also the problem of establishing a decision making mechanism to select the priorities that will dictate future allocations of a limited amount of water. The western region has reached the point at which the order of those priorities will soon have to be set.

The demands on the West's limited budget of water come from many directions:

- Irrigation of crops
- Livestock watering
- Domestic use (status quo)
- Urban development (growth)

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*Advances in the technologies such as processing oil shale while still underground hold promise of reducing the water required by one-half or more; also, dry cooling towers in coal conversion processes, although considerably more expensive than the contemplated wet cooling, could reduce water use.

- Industrial production
- Aesthetic values
- Recreational use
- Energy development

West of the 100th meridian, there is an imminent water budget dilemma that will pit the many needs in direct competition. The primary contributing factors to this competition are:

- Generally arid conditions (precipitation of approximately 14 inches per year)
- Population growth
- Increasing use of irrigation in agriculture
- Federal subsidies of water that result in cheap irrigation water for agricultural projects
- Stated national goal of reducing dependence on foreign sources of energy, with consequent interest in new domestic sources.
- Extensive coal and oil shale resources in this arid region.
- Rising interest in protection of the fragile environment.

In view of this competition, some hard decisions will have to be made affecting different people with different needs. How does the energy-poor New Englander feel about the Montana rancher whose land is being stripped of its character? How does that rancher feel about gasoline shortages in Los Angeles? These decisions will have both regional and national implications, and presently existing laws and institutions may not be up to the task of making the necessary choices. This chapter sets out the nature and sources of the complex problems implicit in western water for energy development.

B. Water Rights and the Federal Government

A major factor in the issue of water for energy in the West is the role of the federal government--both as a claimant to certain amounts of water, and as an institutional disburser of water. From the perspective of the western states, a more accurate statement would be the federal government as claimant to uncertain amounts of water. The situation is so unsettled that neither private investors nor state governments can act with confidence in planning projects where water will be needed.

This section explores the source and dimensions of the federal claims, the conflicts created by them, and the implications of the situation for energy development.

1. Scope of Federal Water Rights

When the United States government obtained the territories that are now the western states, it assumed sovereign dominion and power over all the land, mineral resources, and water. The government encouraged development of the new territory through homesteading and stock grazing land grants, and new states were carved out of the territories. Of the original federal domain, much of the land continues to be property of the United States. Table 19-1 shows the percentages of federally owned land in the mineral rich states of Colorado, Wyoming, and Montana:[1] Of greater significance is the contribution that federally owned lands make to natural water runoff in the major river basins of the West--66 percent of the Missouri River Basin and 96 percent of the Upper Colorado River Basin.[1] From a strictly proprietary standpoint, the federal government has a powerful equitable argument for ownership and control over waters arising on "its" property. The U.S. Constitution, in fact, gives Congress the power

to dispose of and make all needful Rules and Regulations respecting the territory or the Property belonging to the United States; and nothing in this Constitution shall be so construed as to prejudice any claims of the United States....[2]

Table 19-1

PERCENTAGE OF FEDERALLY-OWNED LAND IN COLORADO, MONTANA, AND WYOMING

State	Federally-Owned Land (%)
Colorado	36.3
Montana	29.6
Wyoming	48.2

Other sources of federal power over water are also found in the Constitution. Indeed, the war power has been relied upon to justify the Tennessee Valley Authority project.[3,4] Under the supremacy clause, treaties are superordinate to state law; thus, federal power exists to construct improvements on international watercourses pursuant to a treaty obligation, irrespective of state law.[5] The general welfare clause of the Constitution has been cited as authority for federal action vis-á-vis a privately held water right.[4,6] Federal power over waters capable of use as interstate "highways" (waterways) arises from the commerce clause of the Constitution.[5] An early Supreme Court case held that this power to regulate commerce necessarily includes control over navigation.[7] Thus, Congress may control the navigable waters of the United States and keep them open and free.

Of the above impressive federal powers over water, all but two would--if exercised to the detriment of a privately held right--result in

compensation being paid by the federal government for that private loss. Exercise of federal power over navigable waters would not result in compensation being paid to one whose loss occurs with the exercise of the power:

> Ownership of a private stream wholly upon the lands of an individual is conceivable; but that running water in a great navigable stream is capable of private ownership is inconceivable.[8]

That is, no power resides in an individual to acquire a property right in a navigable stream; therefore there can be no taking away of said right and no compensation would be paid. Similarly, exercise of federal power over a federally-owned proprietary water right could not result in an individual loss for which compensation would be forthcoming.

These last two federal powers are most feared by the states because of the extent of the powers and because when they are exercised no compensation is paid to those whose water rights are displaced. Each of these powers will be discussed in turn.

2. Federal Power Over Navigable Streams

Federal power over large navigable streams such as the Mississippi or Delaware Rivers seems reasonable since such waterways have served as highways for interstate commerce throughout our country's history. However, application of the doctrine has been so extensive that true navigability is no longer the test. Thus, a stream is navigable if it can be made so by reasonable improvements.[9] A stream is navigable if it affects the navigable capacity of the mainstream.[10] The definition of a "navigable stream" reaches so far that one must explore in order to find a nonnavigable stream. The impact on state action is clear, for the state's power to authorize appropriation of water "...is limited by the superior power of the [federal government] to secure the uninterrupted

navigability of all navigable streams within the limits of the United States."[10] The extended definition of navigable streams has potentially provided Congress with the necessary tool to establish sweeping national water legislation with, e.g., a "Federal Water Board" reviewing every application for water, superseding all prior state allocations--and no compensation would have to be paid.[11]

3. Federal Properietary Water Rights

For the few nonnavigable streams that escape the definition extension discussed above, or for all western streams arising on federal lands--in the event Congress does not establish plenary power over the nation's waters--the power of the Congress under the property clause to deal with its "water" property is impressive.

As previously described, federal land holdings in the West are substantial. The underlying force of the proprietary federal claim to western water is based on the argument that unless and until the United States gives up control or ownership of such lands and waters, they remain under the control of the federal government.

It is argued that, relative to these lands, federal legislation of 1866,[12] 1870,[13] and 1877 (the Desert Land Act)[14] served to sever federal water from the federal land, making the water available for disposition through the laws of the respective states. Support for the argument came from the U.S. Supreme Court in California-Oregon Power Company v. Beaver Portland Cement Co.:[15]

> The fair construction of the provision now under review is that Congress intended to establish the rule that for the future the land shall be patented separately...with the result that the grantee will take the legal title to the land conveyed, and such title, and only such title, to the flowing waters thereon as shall be fixed or acknowledged by the customs, laws and judicial decisions

> of the state of their location.... What we now hold is that following the Act of 1877, if not before, all non-navigable waters then a part of the public domain became publici juris, subject to the plenary control of the designated states....

The language seems clear. However, subsequent cases have had the result of severely weakening the message. The first warning to the states came in Federal Power Commission v. Oregon,[16] known as the Pelton case. In Pelton the Supreme Court acknowledged that the Desert Land Act severed the water from the land, but the Court made a critical distinction between "public lands" and "reserved lands," holding that the Act applied only to public lands. Public lands, the Court said, are those lands owned by the federal government that are subject to disposal under federal public land laws, e.g., land available for homesteading or mining. Reserved lands are not so subject, but are those lands being held by the federal government for a particular purpose--e.g., national recreation areas, national forests, national wildlife preservation areas, and petroleum reserves for national defense.

Federal power to reserve water for these public land reservations was first recognized in Winters v. United States.[17] The Supreme Court held that, in the case of the Indian reservation before it, even though the subject of water rights was not mentioned in the documents used to create the land reservation, there existed an implied intent on the part of the federal government to reserve sufficient water arising on traversing or bordering the Indian land to make the land usable. The Court said:

> The power of the government to reserve the waters and exempt them from appropriation under the state laws is not denied and could not be....,[10] That the government did reserve them we have decided....

In a federal district court case involving a federal land reservation in Nevada for the United States Navy,[20] Nevada attempted to force the United States to seek a state water permit before taking water from the land. Again, the court held that there was no requirement for compliance with state law--the act of reserving the land for military purposes removed the land and water from the Desert Land Act and indicated an intent to reserve sufficient water for the purposes of the land reservation.

The Supreme Court addressed the issue again in Arizona v. California,[21] in which several kinds of federal reservations were before the Court. After affirming the validity of the Winter's doctrine in the Indian water question before it, the Court upheld the Special Master's finding that

> The principle underlying the reservation of water rights for Indian Reservations [is] equally applicable to other federal establishments such as National Recreation Areas and National Forests. We agree...that the United States intended to reserve water sufficient for the future water requirements of the Lake Mead National Recreation Area, the Havasu National Wildlife Refuge, the Imperial National Wildlife Refuge and the Gila National Forest.[22]

The Court proceeded to describe a quantified standard for Indian reservation water related to the number of irrigable acres, but left unmeasured the water allocation for the other federal reservations, saying only that they shall have an amount of water "reasonably needed to fulfill the purpose" of the reservation.

The Court also reiterated the Winter's holding that the effective date for determining the priority of these water rights is the date the land was withdrawn from public land status, i.e., the date the reservation was created. As a result, water appropriations made prior to such date are vested in the appropriator, but appropriations made

subsequent to that date are not vested and could be subject to taking without compensation through exercise by the federal government of its water rights.

4. Summary of Federal Water Power

The federal government has the constitutional power to develop, regulate, and allocate--including making allocations to itself--all western water resources, and it can do so irrespective of state laws. When acting under the commerce clause's navigation power, the government need pay no compensation for disrupted private investments.

Furthermore, the federal government can withdraw large tracts of its western land from public sale or lease. These reservations have a water right in an amount necessary to accomplish the purposes of the reservation, and the priority of the water right is the date of the land withdrawal. Any private water rights acquired subsequent to that date are junior to the federal right and can be usurped without payment of compensation.

5. Federal Reserved Lands in the Oil Shale Region

The operation and impact of federal power is seen in the oil shale region of the Upper Colorado Basin. Seventy-two percent of the land in the region is owned by the federal government, and that federal land contains 79 percent of the region's oil shale.[23] Of the total federal land in the region, reservations have been carved out (1) for future Navy fuel needs[24] and (2) for purposes of "investigation, examination and classification."[25] The Naval Oil Shale Reserves were clearly made for the contemplated development of the hydrocarbon resource. If the Arizona v. California[21] "purpose of the reservation" test is applied to determine the amount of water implicitly reserved by the action of the

Executive Orders, the result is an amount of water needed to support the mining and retorting operation. This figure has been estimated at not less than 200,000 acre-ft per year.[26] The priority of the federal water right in this amount dates from the issuance of the Executive Orders establishing the reservations. Again, private rights acquired after those dates are junior to the federal right.

The reservation made in this region by the 1930 Executive Order "...for the purposes of investigation, examination, and classification" is less easily handled under the Arizona v. California test. It is argued that "investigation, examination, and classification" are bare administrative geological functions requiring very little water, and that there was no purpose stated encompassing government development of oil shale in commercial quantities.[27] If this argument is accepted, then a new statement by the federal government would be necessary to the effect that commercial development of the oil shale resource on the reservation tract is the federal purpose. The federal government could then have the necessary water, but the priority date of the water right would be the date of the new statement rather than the 1930 date of the original Executive Order. Private water rights derogated by the "newly contemplated" oil shale development would be senior to the federal rights and therefore would have to be compensated in the taking by the federal government.

6. Implications of the Federal Power

The amount of water for all the various "purposes" of federal reserved land in the West is a matter of speculation. For example, it may be argued that a purpose of the extensive national forests reservations is the production and control of water, thereby creating a federal water right in the total amount of the water arising on that forest land.

One study[28] has pointed out that

> The federal theories underlying reservations and navigation servitude assume that the United States can leave its ownership or authority in suspended animation and can call it in piecemeal or in toto whenever it feels that the time has come for a project....

The uncertainty of that "suspended animation" has angered and frustrated state authorities in their efforts to deal with both state interests in water and the interests of their private citizens.

7. Attempts at Resolution

Colorado has recently tried to remove federal water rights and interests from suspended animation in particular cases. A little used federal law states the following:[29]

> Consent is given to join the United States as a defendent in any suit (1) for the adjudication of rights to the use of water of a river system or other source, or (2) for the administration of such rights, where it appears that the United States is the owner of or is in the process of acquiring water rights by appropriation under state law, by purchase, by exchange, or otherwise, and the United States is a necessary party to such suit. The United States, when a party to any such suit, shall (1) be deemed to have waived any right to plead that the state laws are inapplicable or that the United States is not amenable thereto by reason of its sovereignty, and (2) shall be subject to the judgments, orders and decrees of the court having jurisdiction,...

Colorado did include the United States as a party in a state court water rights adjudication and the United States refused to participate. The matter ultimately was carried to the U.S. Supreme Court where Colorado prevailed.[30] [31] The victory is a limited one, however, for the decision does not give the states power to quantify federal

water rights generally.* The result is a mechanism for a slow, painstaking, expensive, ad hoc measuring of federal water claims, with the federal government unrelenting in its point of view. Now that the case is back at the state court level (to where the U.S. Supreme Court sent it saying, "Proceed") the federal government is listing its claims in vague and expansive terms. Typical is the federal claim for its water rights in the Arapaho National Forest in Colorado:

> The United States of America hereby claims certain quantities of the surface, ground and underground waters, both tributary and nontributary, which were unappropriated as of the reservation dates.... The United States claims direct water rights, storage water rights, transportation rights and well rights for purposes which include, but are not limited to, the following: growth, management and production of a continuous supply of timber; recreation; domestic uses; municipal and administrative-site uses; agriculture and irrigation; stock grazing and watering; the development, conservation and management of resident and migratory wildlife resources including birds, fishes, mammals, and all other classes of wild animals and all types of aquatic and land vegetation upon which wildlife is dependent; fire fighting and prevention; forest improvement and protection; commercial, drinking and sanitary uses; road watering; watershed protection and management and the securing of favorable conditions of water flows; wilderness preservation; flood, soil and erosion control; preservation of scenic, aesthetic and other public values; and fish culture; conservation, habitat protection, and management. With respect to the category of fish culture, conservation, habitat protection, and management, the United States claims the right to the maintenance of such continuous, uninterrupted flows of water and such minimum stream and lake levels as are sufficient in quantity and quality to:

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*Left unanswered is the effect of the statute on permit-type states, such as Wyoming and Montana, where water rights are determined administratively, not judicially.

(1) Insure the continued nutrition, growth, conservation, and reproduction of those species of fish which inhabited such waters on the applicable reservation dates, or those species of fish which are thereafter introduced.

(2) Attain and preserve the recreational, scenic, and aesthetic conditions existing on the applicable reservation dates, or to preserve those conditions which are thereafter caused to exist.[33]*

It is important, after catching a breath, to emphasize the government's early-stated caveat that the federal claim is "...not limited to...." the purposes stated in this exhaustive list. Stunned by the vigor of the federal government's activities in the aftermath of the Eagle County decision, the Colorado Water Conservation Board passed the following resolution:†

> Whereas the federal government has now filed numerous claims for water rights in the State of Colorado...to establish federal claims to much of the water originating in Colorado...; and
>
> Whereas the federal government is claiming an unspecified and unknown amount of water...; and
>
> Whereas the granting of the claims sought by the United States could seriously jeopardize the existing system of water rights within the State of Colorado, could create a dual system of administration and decrees, could require water users needlessly to re-adjudicate rights already acquired and decreed under state law, could adversely affect Colorado's rights under the Colorado River Compact and the Upper Colorado River Basin Compact, and will cast an almost impossible burden

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*Taken directly from the U.S. filing papers in the Colorado Court. The lengthy quote is felt necessary to make the point.

†Colorado Water Conservation Board; Resolution passed at the meeting of January 18, 1973. (Emphasis added.)

> upon the citizens of this state in attempting to protect their individual water rights;
>
> Now therefore, be it resolved...that the Board does hereby recommend to the Governor...[etc.]...that all steps necessary and proper, including appropriate funding, be taken and authorized to adjudicate them and thereafter administer them in accordance with state law....

The Board is calling for the fiscal resources to oppose the federal water lawyers. The gauntlet was thrown when the open-ended federal claims were filed.

There have been numerous attempts in the U.S. Congress to legislate a solution to the problem of seemingly open-ended federal water claims, but none of the measures was passed.[33] For the most part, they were introduced by western congressmen seeking to subject virtually all federal water claims to state law.

Nevertheless, most people agree that something must be done to remove the federal water cloud. Two national studies have called for congressional action to require federal cooperation in pursuit of a solution. The Public Land Law Review Commission recommended a complete quantification of all federal water claims, including public notice of all prospective water uses under federal reserved rights; this group also recommended that provision be made for payment of compensation where the exercise of a federal right would interfere with water rights vested under state law prior to the 1963 decision in Arizona v. California.* In its 1973 report,[34] the National Water Commission called for a quantification only of existing federal water uses,† with future reserved rights

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*Reference 1, pp. 147-149.

†See Sect. 10 for discussion of National Water Commission treatment of the intricate Indian water rights issue.

to be exercised through compliance by the federal government with the law of the state in which the federal project is located; the priority of the federal water right so acquired would be the date of the application for state permit or otherwise as determined by state law.

Legislation has been drafted by the Land and Natural Resources Division of the U.S. Department of Justice at the request of the Secretary of the Interior, acting in his capacity as Chairman of the U.S. Water Resources Council. The proposed act seeks "...to provide for the inventorying and quantification of the reserved, appropriative, and other rights to the use of water by the United States...,"[35] including an inventory of Indian water rights. The act provides for judicial review in federal court of the administrative determinations made in pursuit of the comprehensive inventory. No provision is made for the payment of compensation and there is no intent to subject federal rights to state law:

> ...more than ever before, in this day of awareness of ecological necessities and environmental and other values which may be antithetical to the economic objectives of many local water developments, it would seem clear that the public interest does not necessarily require that all future development under the United States reserved rights yield to immediate development under state law.[35]

A noted commentator, Dean Frank J. Trelease, has pointed out that such a proposed inventory could cause great problems in that the federal agencies concerned

> ...may prepare inventories which are grandiose claims of a pie-in-the-sky order, which may confirm the worst fears of state planners [and energy developers] who will see little left for them, and which may unnecessarily becloud titles to unused waters, perhaps deterring development even more than the present uncertainties.[36]

The response of the Department of Justice to this criticism is that the provision for adjudication of claims made by the administrative