APPENDICES

DENVER REGIONAL ENVIRONMENTAL IMPACT STATEMENT FOR WASTEWATER FACILITIES AND THE CLEAN WATER PROGRAM

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII, DENVER

Appendices

To the

Denver Regional

Environmental Impact Statement

For

Wastewater Facilities

and the

Clean Water Program

U.S. Environmental Protection Agency
Region VIII
Denver, Colorado

Contents

APPENDIX A

SUPPLEMENTAL INFORMATION ON EXISTING ENVIRONMENT

Appendix A is intended to provide reviewers having special interests and needs with supplimentary information and data which supports many of the evaluations and value judgments made during the preparation of Section II, THE EXISTING ENVIRONMENT. Use of this appendix to present supplimentary information has significantly shortened the environmental inventory in the main body of the EIS. The goal of this action has been to highlight the most important and sensitive aspects of the region's environment in the EIS so that issues surrounding the proposed projects and EPA's fund activities can be tentatively identified early in the assessment process. Early identification of tentative issues is critical in focusing the EIS so that it becomes a useful policy-making tool as well as a decision-making tool.

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APPENDIX TABLE A-1 CLIMATE DATA SUMMARY

TEMPERATURES

Mean annual temperature -- 11.3°C [52.3°F]
Annual temperature range -- -34°C [-30°F] to 40°C [105°F]

Mean monthly diurnal temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
°C	1.2	1.8	3.6	8.8	14.7	20.8	23.6	22.9	18.4	12.1	4.7	2.6	
[°F]	34.1	35.3	38.5	47.8	58.4	69.4	74.5	73.2	65.1	53.7	40.5	36.6	
No. days with temperature - 0°C [32°F]	25	22	21	10	1	+[a]	0	0	+	5	18	24	126

Freeze threshold temperature °C	[°F]	Mean number of days between date of last spring occurrence and first fall occurrence
0	[32]	166
-2.2	[28]	192
-4.4	[24]	212
-6.7	[20]	231
-8.9	[16]	239

Note: The symbol + indicates a range between 0 and .5.

Growing season -- April through September.

PRECIPITATION

Precipitation season (69% annual precip.) -- April through September
Average annual precipitation -- 31 cm [12 in]

Monthly mean precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
mm	8.6	16.3	20.6	36.8	65.0	25.9	37.3	30.5	19.3	24.4	14.2	10.7
[in.]	0.34	0.64	0.81	1.45	2.56	1.02	1.47	1.20	0.76	0.96	0.56	0.42

APPENDIX TABLE A-1 CLIMATE DATA SUMMARY (Continued)

Frequency of maximum precipitation, years	6-hour total mm	6-hour total [in.]	24-hour total mm	24-hour total [in.]
2	36 to 41	[1.4 to 1.6]	46 to 56	[1.8 to 2.2]
5	46 to 51	[1.8 to 2.0]	61 to 71	[2.4 to 2.8]
10	56 to 64	[2.2 to 2.5]	66 to 86	[2.6 to 3.4]
25	71 to 76	[2.8 to 3.0]	86 to 97	[3.4 to 3.8]
50	76 to 86	[3.0 to 3.4]	97 to 117	[3.8 to 4.6]
100	86 to 97	[3.4 to 3.8]	107 to 127	[4.2 to 5.0]

Snowfall Season -- November through April
Average annual snowfall -- 145.5 cm [57.3 in]

Monthly mean snowfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
cm	15.7	23.6	29.7	27.2	3.0	0.3	T	T	3.3	8.1	17.5	17.0
[in.]	6.2	9.3	11.7	10.7	1.2	0.1	T	T	1.3	3.2	6.9	6.7

Thunderstorms, mean number of days	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	0	+[a]	+	1	6	10	12	8	4	1	+	0	43

Note: The symbol + indicates a range between 0 and .5.

HUMIDITY/EVAPOTRANSPIRATION

Relative humidity Percent	Occurrence (percent of time)
0 to 29	27
30 to 49	28
50 to 69	23
70 to 79	10
80 to 89	9
90 to 100	4

Annual evapotranspiration rate -- 610 mm [24 in]

APPENDIX TABLE A-1 CLIMATE DATA SUMMARY (Continued)

WINDS

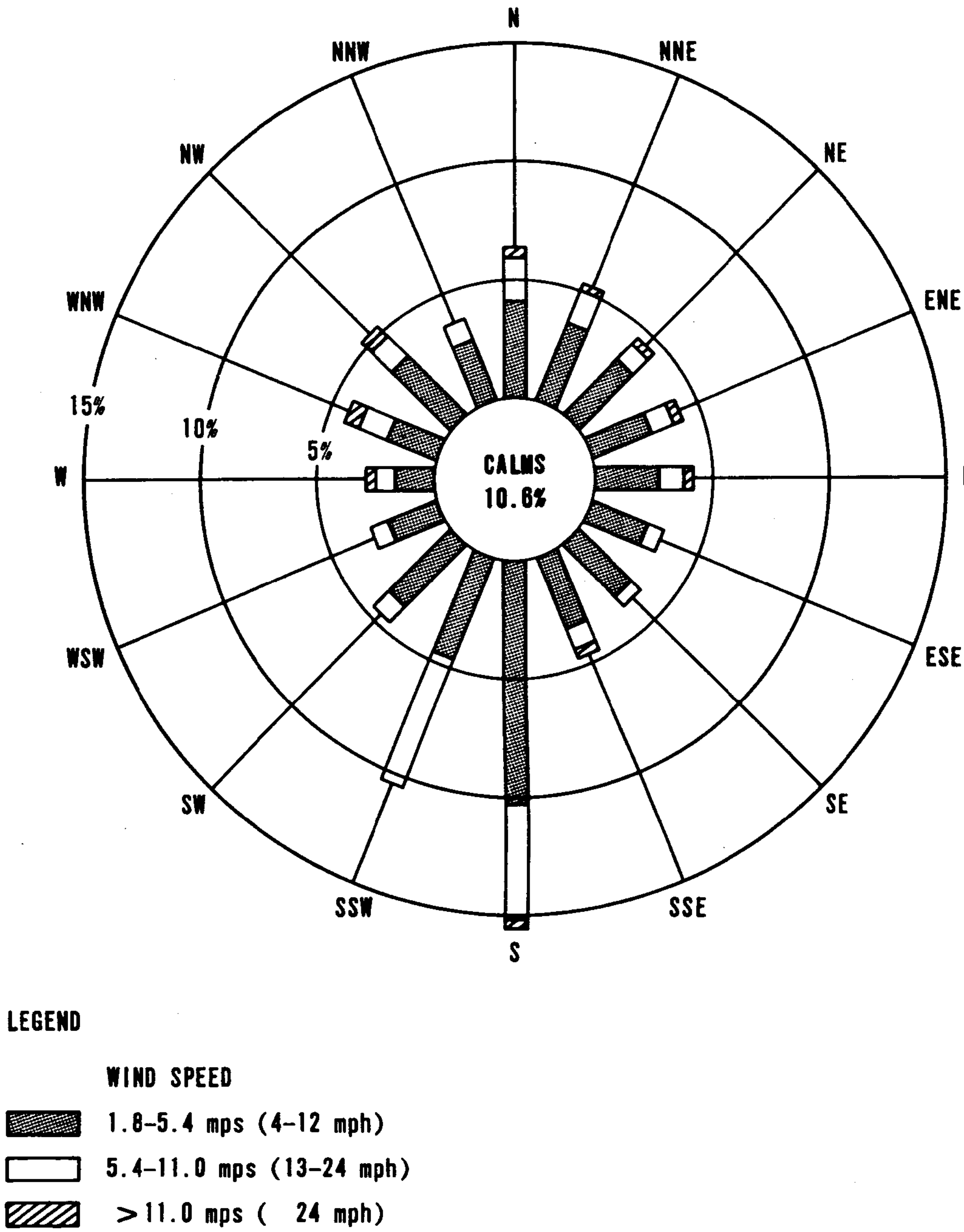
Mean hourly speed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean
mps[o]	4.3	4.5	4.8	4.7	4.4	4.4	4.0	3.7	3.7	3.8	4.3	4.5	4.2
[mph]	9.6	10.1	10.7	10.6	9.9	9.8	9.0	8.3	8.3	8.5	9.7	10.0	9.5
Prevailing direction	S	S	S	S	S	S	S	S	S	S	S	S	S

Fastest speed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean
mps	18	22	24	23	19	21	20	18	21	18	18	23	24
[mph]	41	49	53	52	43	47	44	40	47	40	40	51	53
Direction	NW	NW	NW	SE	NW	S	SE	SW	NW	SW	NE	NE	NW

o: mps = meters per second

Frequencies of wind speed in % of time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean
					Monthly percent								
0 - 1 mps [0 - 3 mph]	9.6	9.2	8.6	8.0	9.1	9.8	11.6	14.3	13.1	13.4	10.1	10.2	10.6
2 - 3 mps [4 - 7 mph]	25.6	25.1	23.2	23.5	24.8	25.2	28.2	27.6	30.4	33.5	26.9	25.8	25.7
4 - 5 mps [8 - 12 mph]	34.4	33.0	33.5	31.4	33.4	34.0	35.4	35.6	34.1	33.0	33.6	34.2	
6 - 7 mps [13 - 18 mph]	24.2	24.1	22.7	24.3	24.2	23.0	20.5	19.3	18.9	16.6	23.1	22.2	
8 - 10 mps [19 - 24 mph]	4.6	5.8	7.0	7.9	6.3	3.4	2.6	2.9	2.9	2.7	4.4	5.2	
11 - 13 mps [25 - 31 mph]	1.4	2.4	3.6	3.9	1.6	1.5	0.8	0.7	0.6	0.6	1.4	1.8	
14 - 16 mps [32 - 38 mph]	0.2	0.4	1.1	0.7	0.4	0.3	0.1	+[a]	0.1	0.3	0.4	0.5	
17 - 20 mps [39 - 46 mph]	0	+	0.2	0.2	+	+	+	0	0	0.1	+	0.2	
≥ 21 mps [≥ 47 mph]	0	0	0	+	0	0	+	0	0	0	0	0	

[a] + = < 0.5 percent.



ANNUAL FREQUENCIES OF WINDS
OF VARIOUS VELOCITIES AT
STAPLETON AIRPORT, DENVER COLORADO

ODOR

Odor control is regulated by the Air Pollution Commission of the Colorado Department of Health through Odor Emission Regulation #2 (Reference 126). This regulation sets forth three types of odor limits: for residential or commerical areas, odorous substances must be undetectable from beyond the property line of the emission source after having been diluted with 7 volumes of odor-free air; for other areas, a dilution of 15 volumes of odor-free air must render the odor undetectable. A special regulation exempts agricultural and manufacturing processes, provided the best practicable methods have been employed to control odors. For all odor sources, there is an upper limit which must not be exceeded: odors must not be detectable after having been diluted with 127 volumes of odor-free air.

In the Denver area spring and summer months are characterized by high temperatures and low wind conditions which contribute to odor control problems. The biological processes, with their attendant odor problems, utilized in some wastewater treatment facilities are generally accelerated by increase in temperature. In water bodies receiving nutrient run off, such as treatment plant lagoons and natural streams experiencing low-flow conditions, eutrophication and decay of algal growths can produce unpleasant odors. Winds of low velocity may fail to adequately disperse and dilute odors as they move away from an odor source.

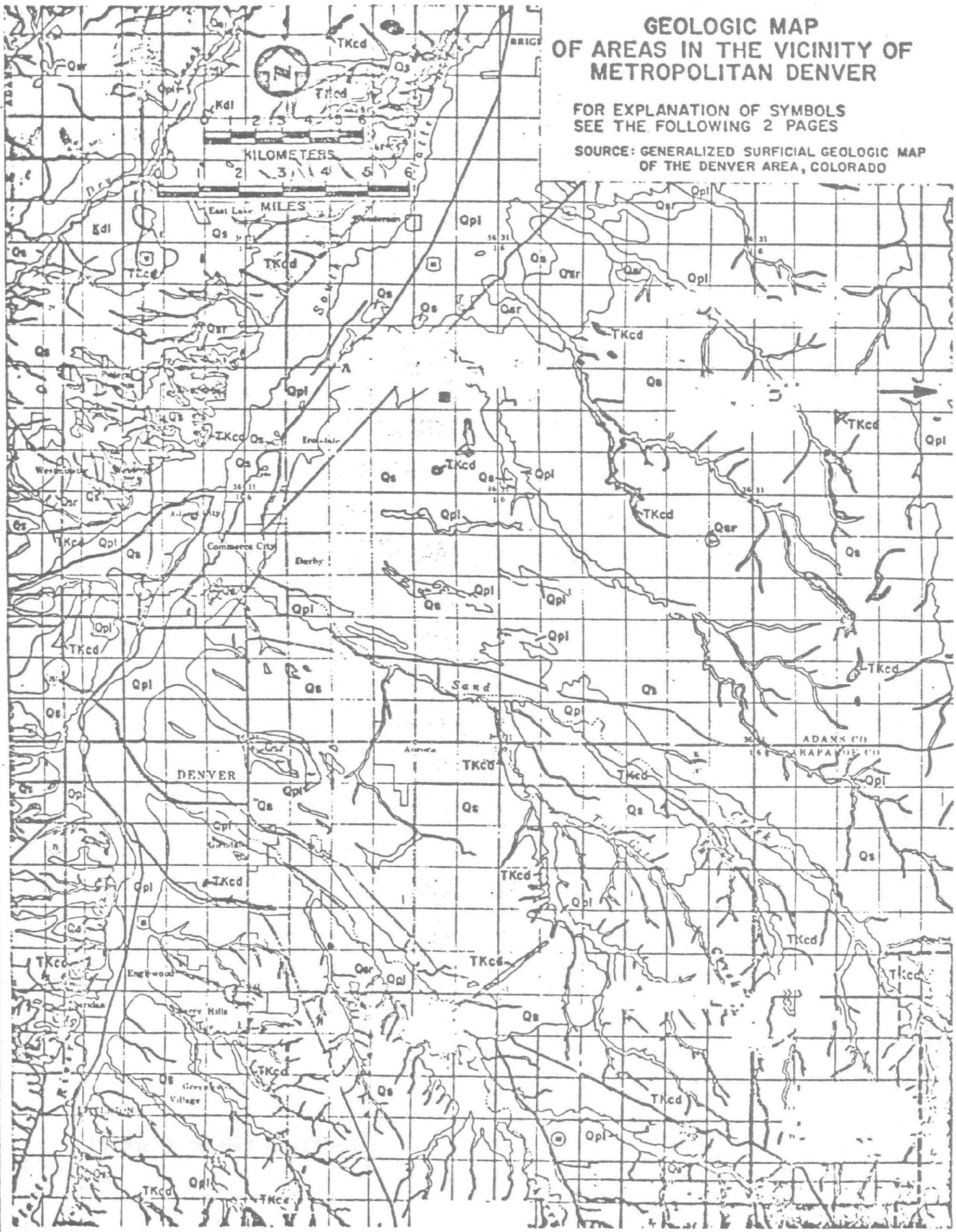
GEOLOGY

The strata of the Denver Basin dip slightly toward the east, while the strata of the Front Range have a steep dip. The two geologic regions are separated by a north-northwest, south-southeast trending zone of sharp, almost vertical folds on the western edge of the Denver basin at the base of the foothills. Surface geology of the Denver area is shown in Appendix Figure A-2. Unique and significant geological structures and formations are highlighted on Map E. These features are described in Appendix Table A-2.

Most of the surface of the study area is covered by unconsolidated Quaternary deposits which range in thickness from 0 to 20 m [0 to 66 ft]. Early in the Quaternary, before the Wisconsin glaciation, debris from the Front Range formed large deltas in the Denver Basin. The deltas included layers of silt, sand and gravel as well as some volcanic ash. The pre-Wisconsin Quaternary deposits are designated as Qsi on the geologic map presented on Appendix Figure . The water yield of these deposits is small and generally of poor quality.

The entire study area is underlain by the Fox Hills Sandstone, a marine deposit of sandstone and shale laid down during the Upper Cretaceous. Calcarious material is found throughout the formation. The boundary between the Fox Hills Sandstone and the Laramie Formation is not sharp; it grades from the marine sediments of the Fox Hills Sandstone to the brackish and freshwater deposits of the Laramie. The Laramie Formation is characterized by interbedded layers of shale, sandstone, limestone and coal. The Fox Hills Sandstone and the Laramie Formation serve as a high-yield aquifer. The Laramie is unconformably covered by unconsolidated Quaternary deposits in the Weld County area, and farther south, in Adams and Arapahoe counties, by intertongued deposits of Dawson Arkose, Arapahoe Sandstone and Denver Formation. (References 819, 820, 821, 973, 974 and 975.)

APPENDIX FIGURE A-2. SURFACIAL GEOLOGY



APPENDIX FIGURE A-2 (Continued)

E X P L A N A T I O N

QUATERNARY

Holocene

Qs

Loess, eolian sand, colluvium undifferentiated

Wind-deposited silt, sand; sand and cobbles on foothill slopes. Silt and sand deposits 0-40 feet thick, sand and cobbles as much as 10 feet thick. Saturated sand and gravel may yield 1 to 5 gpm to wells

Pleistocene and Holocene

Qpl

Post-Piney Creek alluvium, Piney Creek Alluvium, pre-Piney Creek alluvium, Broadway and Louviers Alluviums

Sand, gravel, silt, and clay. Deposits range from 0-60 feet thick. Saturated sand and gravel yield as much as 2,000 gpm to wells. Chemical quality of water generally good

Pleistocene

Qsr

Slocum, Verdos, and Rocky Flats Alluviums

Reddish-brown silty clay, silt, sand, pebble lenses, and loess. Coarse gravel and sand and volcanic ash underlie high terrace remnants. Unit may exceed 50 feet in thickness locally. Yields 1 to 5 gpm to wells where materials are saturated. Gravel and sand near Barr Lake yield as much as 200 gpm to wells. Water generally of poor quality, contains excessive concentrations of fluoride

TERTIARY

Paleocene and Oligocene

TKcd

Castle Rock Conglomerate, upper part of Dawson Formation, and upper part of Denver Formation

Gray, brown, tan, and greenish-gray shale, clay, and siltstone, and numerous lenticular beds of light-colored conglomerate and sandstone. Andesitic mudflow breccias common in vicinity of Table Mountains and Green Mountain. Beds of sandy limestone, lignite, coal, and carbonaceous shale are common. Unit ranges in thickness from 300 to 1,400 feet. Yields less than 25 gpm to wells in most of the area, but as much as 150 gpm in southeast part. Locally water contains high concentrations of dissolved solids, iron, radioactive constituents, and hydrogen sulfide gas

CRETACEOUS

Upper Cretaceous

Kdl

Lower part of Dawson Formation, Arapahoe Formation, and lower part of Denver Formation

White to yellow arkosic sandstone and conglomerate interbedded with gray, green, and red shale and claystone. Contains alluvial and mudflow andesitic detritus. Conglomerate beds thicken in upper part, and are thicker and more numerous toward southeast part of the basin. Unit ranges from 500 to 1,200 feet thick. Yields to wells average 100 gpm and are as much as 600 gpm. Water generally of good quality

Kl

Upper part of Laramie Formation

Blue-gray silty shale, thin silty sandstone, limestone, and coal; coal thickest in lower part. Yields 1 to 2 gpm of poor quality water to wells. Water contains hydrogen sulfide, iron, and methane

TERTIARY

Paleocene(?)

Tv

Volcanic rocks

Lava flows on Table Mountains, vent source near Ralston Creek, and ash flow tuffs near Castle Rock. Ash flow tuffs underlie Castle Rock Conglomerate. Not known to be saturated

Geological map of areas in the vicinity of Metropolitan Denver (cont'd)

APPENDIX FIGURE A-2 (Continued)

CRETACEOUS

Upper Cretaceous

Klf

Lower part of Laramie Formation and Fox Hills Sandstone

Medium-grained sandstone (60-80 feet), overlying and grading into finer grained thin-bedded sandstone interbedded with siltstone and shale (30-100 feet). Fine grained quartzose sandstone, siltstone, shale (60-120 feet). Wells penetrating entire unit generally yield 100 gpm and a few yield as much as 400 gpm. At places water may contain objectionable amounts of methane, hydrogen sulfide, iron, and fluoride

Lower Cretaceous

Kpb

Pierre Shale, Niobrara Formation, and Benton Shale

Gray, blue, and black shale, sandy shale, and thin limestone; some silty sandstone, bentonite seams, chalky marl, and limestone. Units may total 8,000 feet in Denver Basin. Fractured zones in shale may yield 1 to 2 gpm of poor quality water to wells

Kd

Dakota Group

Upper 100 feet gray-white fine- to medium-grained sandstone, thin-bedded to massive. Middle 150 feet dark-gray silty carbonaceous shale, contains refractory clay. Lower 60 feet gray coarse sandstone, locally conglomeratic, crossbedded. Sandstone yields 5 to 30 gpm to wells near outcrop. Water contains excessive iron locally

PENNSYLVANIAN THROUGH JURASSIC

JPr

Sedimentary rocks undifferentiated

Includes Upper Jurassic Morrison (300 feet) and Ralston Creek (120 feet) Formations; Triassic(?) and Permian Lykins Formation (400 feet); Permian Lyons Sandstone (200 feet); and Lower Permian and Upper and Middle Pennsylvanian Fountain Formation (1,200 feet). Lyons Sandstone, shown by stipple, generally yields 5 to 10 gpm, and as much as 80 gpm to wells near outcrop areas. Fountain Formation sandy conglomerate may yield 1 to 5 gpm to wells. Water may contain excessive iron and fluoride

PRECAMBRIAN

p€r

Igneous and metamorphic rocks undifferentiated

Granite, gneiss, schist, quartzite, pegmatite, quartz veins, intrusive igneous rocks. Yield 1 to 5 gpm of generally good quality water to wells that tap fractures or weathered zones

Contact

Fault

Geological map of areas in the vicinity of Metropolitan Denver (cont'd)

APPENDIX Table A-2 GEOLOGICAL STRUCTURES AND FORMATIONS IN THE DENVER AREA[a]

Geologic name, map symbol[a] and description

THE FLATIRONS (2) Natural, Scenic

The upraised Fountain Formation dips steeply to the east here.

DEVILS THUMB (3) Natural, Scenic

This resistant sandstone outcrop of the Fountain Formation lies immediately to the north of the Hoosier Fault which trends northwest along Shadow Canyon.

MARSHALL MESA (4) Natural

This sandstone shelf on the Laramie and Fox Hills Formations is the site of an unusual plant community.

ROCKY FLATS (6) Natural

Rocky Flats, a remnant of a high-level pediment, takes its name from a thick fanshaped deposit of coarse gravel that has its apex near the mouth of Coal Creek Canyon. Rocky Flats is similar to gravel-capped bedrock erosion surfaces elsewhere along the South Platte and Arkansas drainages near the foothills.

COAL CREEK CANYON (7) Natural

Coal Creek is named for coal-bearing rocks which it crosses east of the mountains.

RALSTON BUTTES (8) Natural, Scenic

Ralston Buttes are eroded from upturned beds of the Fountain Formation. A large fault zone along Ralston Creek helped guide the dissection.

LARAMIE FORMATION (9) Natural

As the Rocky Mountains were uplifted, normally horizontal strata were tilted, folded, and fractured. Here sandstones of the nearly vertical Laramie Formation form an imposing hogback near Leyden Gulch. The Laramie Formation has been exploited for its commerical clay deposits and subbituminous coal.

NORTH TABLE MOUNTAIN (15) Natural, Scenic

SOUTH TABLE MOUNTAIN (15) Natural, Scenic

These flat-topped mountains are capped by remnants of basaltic lava flows that probably originated from a volcanic vent near Ralston Reservoir during Tertiary time. The slopes of both mountains are littered with landslide debris, and some landslides have affected irrigation ditches, railroads, and highways.

CLEAR CREEK CANYON (24) Natural, Historic

Clear Creek has cut a narrow canyon through hard Precambrian rocks between Idaho Springs and Golden.

FOLIATIONS (28) Natural

Foliation and gneissic banding are widely evident in the Precambrian gneisses of the Idaho Springs Formation, especially in Mount Vernon Canyon in the deep roadcuts of Interstate Highway 70 and its frontage road.

MOUNT VERNON CREEK WIND GAP (29) Natural

Ancient Mount Vernon Creek once flowed across the Hogback at this point.

DAKOTA HOGBACK (59) Natural

Large hogback parallel to mountain front
Fossilized leaves, marine fish scales, dinosaur tracks, and ripple marks have been found in the sandstones and shales of the Dakota Sandstone on the eastern slope of the Hogback. On the western side, dinosaur bones have been found in the siltstone and sandstone beds of the underlying Morrison Formation.

RED ROCKS PARK (60) Natural, Historic, Scenic

World-famous Red Rocks Park is eroded from eastward-dipping beds of the Fountain Formation, tilted by the uplift of the Rocky Mountains.

DANIELS PARK AREA (69) Natural, Scenic

Here the highly dissected Castle Rock Conglomerate is underlain by ash flow tuffs and by the Dawson Arkose.

APPENDIX Table A-2 (Continued) GEOLOGICAL STRUCTURES AND FORMATIONS IN THE DENVER AREA[a]

Geologic name, map symbol[a] and description
CASTLE ROCK (73) Natural
Castle Rock is a conspicuous landmark above the town that bears its name.
NORTH FORK OF THE SOUTH PLATTE RIVER (80) Natural, Historic
Buffalo Creek to South Platte Between Buffalo Creek and South Platte, the North Fork of the South Platte River flows across granite of the Pikes Peak batholith. Exfoliation of the granite forms picturesque terrain that includes Dome Rock, Chair Rocks, and Cathedral Spires.

[a]For location see Map G.

Geological Hazard Areas

The most important potential problem related to geologic structures and formations in the Denver area is the shrink-swell characteristics of bentonitic clays found in the Denver-Arapahoe and other formations underlying most of the soils in the area. Soils in the foothills west of Denver have a particularly high shrink-swell potential which places severe natural restrictions on urban development. In other parts of the study area this potential varies from moderate to low.

Shrink-swell potential is an important environmental consideration in determining the suitability of land for urban development because swelling clays provide very poor foundations and they can cause problems such as slippage in steep areas and differential settling. In the steep, western foothills where swelling clay problems are most severe, construction activities need special planning which includes intensive soil testing on each development site. Another, less widespread, geologic hazard, land sliding, is encountered in areas having slopes greater than 25 percent which are supported by clay substrata (see Map C). These areas are found in the same western foothills areas having severe shrink-swell problems discussed above.

Other geologically-related hazards are posed in areas where sand, gravel, clay, stone and coal have been mined in the past. Subsidance and slope instability in the vicinities of the old mining sites are the most likely problems to be experienced. The sites are predominantly located along the northern, western and southern peripheries of the metropolitan area (References 605, 606 and 607).

Finally, faults shown on Map C represent a potential geologic hazard of very low significance due to the consideration that historic seismic activity in the region has been minimal.

APPENDIX TABLE A-3

APPROXIMATE ACREAGE AND PROPORTIONATE EXTENT OF PRIME AGRICULTURAL SOILS IN THE DENVER REGION

Soil Name	% Slope	Acreage	Percent of Total County Acreage
Adams County			
Adena loam	0.3	18,600	2.4
Adena loam	3-5	2,400	.3
Adena-Colby Association	3-5	67,700	8.1
Ascalon loamy sand	0-3	700	.1
Ascalon loamy sand	3-5	1,100	.1
Ascalon sandy loam	1-3	43,300	5.4
Ascalon sandy loam	3-5	17,300	2.2
Ascalon-Platner Association	0-5	7,700	1.0
Ascalon-Vona sandy loams	1-5	30,900	4.0
Dacona loam	0-1	3,100	.4
Dacona loam	1-3	400	*
Loamy alluvial land, moderately wet	0-3	12,400	1.5
Nunn loam	0-1	3,500	.4
Nunn loam	1-3	12,200	1.6
Nunn clay loam	0-1	3,200	.4
Nunn clay loam	1-3	5,100	.6
Platner loam	0-3	39,800	5.0
Platner loam	3-5	17,100	2.1
Renohill loam	1-3	700	.1
Satanta loam	0-1	1,100	.1
Satanta loam	1-3	400	*
Stoneham loam	0-3	1,300	.2
Terry fine sandy loam	0-3	800	.1
Truckton loamy sand	0-3	10,500	1.2
Truckton sandy loam	1-3	14,000	1.6
Truckton sandy loam	3-5	2,800	.3
Ulm loam	1-3	3,900	.4
Ulm loam	3-5	11,400	1.4
Vona loamy sand	0-3	4,300	.5
Vona sandy loam	0-1	4,000	.5
Vona sandy loam	1-3	3,400	.4
Vona sandy loam	3-5	1,400	.2
Weld loam	1-3	103,500	13.0
Total		450,000	55.6

* Less than .05 percent.

Source: DRCOG, Reference 252

	% Slope	Acreage	Percent of Total County Acreage
Arapahoe County			
Adena-Colby fine sandy loams	1-5	1,780	0.3
Adena-Colby silt loams	1-5	30,750	5.9
Baca loam	3-5	920	.2
Bijou sandy loam	0-3	3,330	.6
Bijou sandy loam, wet	0-3	2,000	.4
Bresser loamy sand, terrace	0-3	490	.1
Bresser sandy loam, terrace	0-3	4,280	.8
Bresser loam, gravelly subsoil variant	1-3	914	.2
Bresser-Truckton sandy loams	3-5	31,350	6.0
Buick loam	3-5	7,020	1.4
Edgewater loam	0-3	1,202	.2
Fondis silt loam	1-3	21,393	4.1
Fondis silt loam	3-5	12,620	2.4
Fondis-Colby silt loams	3-5	9,450	1.8
Fort Collins loam	0-3	1,440	.3
Nunn loam	0-3	26,888	5.2
Nunn-Bresser-Ascalon complex	0-3	54,390	10.4
Weld fine sandy loam	1-5	760	.1
Weld silt loam	0-3	16,670	3.2
Weld silt loam	3-5	2,150	.4
Total		229,797	44.0
Boulder County			
Ascalon sandy loam	0-1	1,300	0.5
Ascalon sandy loam	1-3	11,000	4.5
Ascalon sandy loam	3-5	4,800	2.0
Ascalon-Otero complex	0-3	1,200	.5
Ascalon-Otero complex	3-5	2,600	1.0
Calkins sandy loam	0-1	1,600	.7
Calkins sandy loam	1-3	1,700	.7
Colby silty clay loam	1-3	4,300	1.8
Colby silty clay loam	3-5	2,200	.9
Colby silty clay loam, wet	0-3	600	.2
Hargreave fine sandy loam	1-3	1,100	.5
Loveland soils	0-1	4,500	1.9
Manter sandy loam	0-1	400	.2
Manter sandy loam	1-3	2,100	.9
Manvel loam	1-3	2,100	.9
McClave clay loam	0-1	2,300	1.0
Nunn sandy clay loam	0-1	1,700	.7

Soil Name	% Slope	Acreage	Percent of Total County Acreage
Nunn sandy clay loam	1-3	3,400	1.4
Nunn clay loam	0-1	6,800	2.8
Nunn clay loam	1-3	15,300	6.3
Nunn clay loam	3-5	5,300	2.2
Nunn-Kim complex	0-3	2,600	1.0
Valmont clay loam	1-3	5,200	2.1
Valmont clay loam	3-5	1,200	.5
Weld loamy sand	1-4	220	.1
Weld fine sandy loam	1-3	1,400	.6
Weld loam	0-1	500	.2
Weld loam	1-3	3,400	1.4
Weld-Colby complex	0-3	1,900	.8
Weld-Colby complex	3-5	500	.2
Total		93,220	38.5

HYDROLOGY

The study area is within the South Platte River drainage basin. Principal tributaries to the South Platte in the area include Plum Creek, Bear Creek, Clear Creek, Cherry Creek, Sand Creek, Big Dry Creek, Coal Creek, and a tributary of Boulder Creek which flows into the St. Vrain Creek and into the South Platte River north of the study area, drain the northwest portion of the area.

The South Platte River rises in the mountains to the west near the continental divide and has a drainage area approximately 4,713 square miles above the Henderson gage north of Denver. The river is characteristic of snow melt streams; approximately 75% of the annual flow occurs during the spring and early part of the summer months, the remaining 25% of the flow occur during the fall and the winter months. The annual variations of stream discharges are directly related to the snow pack accumulated during the previous winter.

The tributaries of Bear Creek, Clear Creek, Boulder Creek and Coal Creek rise in the western mountains and have the characteristics of a snow melt stream. Cherry Creek, Sand Creek, Big Dry Creek and Plum Creek rise on the plains east of the mountains and join the South Platte River in the vicinity of Denver. The flows in these streams are characteristic of streams that rise on the high plains and respond vigorously to frontal storm and thunderstorm type events.

Natural stream flows generally reach a peak during May or June due to snow melt in the mountains while the natural low flow period is usually in January or February. Low flows on some of the tributaries, however, can be caused by irrigation diversions during August and September.

The historic average daily discharge of the South Platte River, measured at the Henderson gage is 366 cfs. The average daily flows range from 4.4 cfs. during the latter part of the summer months to as much as 110,000 cfs recorded at the Littleton gage south of Denver during a severe flooding situation. Generally, the peak flows recorded during the snow melt period can be as much as 5,000 cfs. Two recent floods on the South Platte River occurred duirng June 1965 and May 1973. The June 1965 flood had a recorded peak discharge of 110,000 cfs and was attributed to a series of severe thunderstorm cells in the headwaters of Plum Creek with minor runoff contribution from the other tributaries. The flood on the South Platte River in May 1973 was a combination of a broad, frontal type storm and a rapid snow melt. The peak discharge was measured at 33,000 cfs.

The South Platte River flows over many different geologic units. The river rises in the precambriam and granite hard rock mountains to the west near the continental divide. Glaciers that laid down extensive deposits of clay and sand and gravel modified the stream valleys and the flow regime of the South Platte River in the mountains. The sand and gravel deposits contain a groundwater reservoir that supports a base flow in the South Platte River. As the river and its tributaries flow from the mountains and onto the plains, the geologic units change from the hard rocks to sandstone and shale, and stream and terrace alluvium. As the streams flow from the mountains, water percolates through the stream bed and recharges the sandstone aquifers that comprise the Denver basin groundwater system. Further onto the plains area, the streams stop losing water to the sandstone aquifers and receive groundwater discharge from shallow groundwater aquifers. Much of the flow in the river and its tributaries during the latter part of the summer months is a result of groundwater discharge from the shallow groundwater aquifers.

Flow in the South Platte River and it's tributaries are heavily regulated by diversions for irrigation, transmountain diversions into the basin, and by numerous reservoirs that store water for irrigation and flood control.

Flows in Plum Creek and the South Platte River south of Littleton, are controlled by the recently completed Chatfield Dam. The Cherry Creek dam divides the upper and lower portions of the Cherry Creek basin. Flows in Cherry Creek below the dam are sometimes comprised entirely of urban runoff. The Bear Creek Lake dam under construction on Bear Creek near Morrison is expected to control the flows on Bear Creek sometime after mid-1977.

At times, the flow in Clear Creek below Golden is primarily from sewage treatment plant effluent. During the summer months, parts of the stream can be dry due to irrigation diversions. Sand Creek is frequently an intermittent stream with periods of no flow. Coal Creek and Boulder Creek, with the exception of where Boulder Creek passes through the town of Boulder, cross primarily agricultural lands.

Standley Lake northwest of Denver controls the upper portion of Big Dry Creek. Normal flows in this tributary are primarily irrigation and irrigation return flows in addition to urban runoff. The lower reaches of the stream pass through predominantly irrigated agricultural lands.

The center of the study area in Denver is heavily urbanized while the perimeter regions around the urban area are agricultural or range land, a significant portion being primarily cropland. Two types of runoff may occur; urbanized runoff from streets and other covered area and agricultural runoff.

Past urbanization has severely constricted some of the drainageways to the point where structural measures are necessary to safely pass the 100-year flood without substantial property damage. In recent years, an increase in flood damage awareness and proper drainage planning is helping to keep the remaining drainageways free from development.

Uncontrolled urbanization increases runoff and the flood damage potential to downstream development. The Urban Drainage and Flood Control District, which covers essetnially the entire planning area, has an increasingly active planning effort to solve or prevent drainage problems. Some of the municipalities and counties within the area have restrictions limiting the peak rate of runoff from developing lands to the historic rate. The basin or region wide effect of requiring individual developments to provide detention to meet historic peak runoff requirements is yet to be determined for the study area. The aggregate effect may be higher peak rates of runoff for downstream reaches because detained hydrographs from individual sub basins are long and flat and are more likely to become additive. Problems are encountered with supervision of construction, responsibility for maintenance and eventual elimination of the controlling mechanisms by third parties. For these reasons, present major drainage planning is based on future basin development and considers that detention requirements will not be effective.

WATER SUPPLY

Water for the study area comes from three major sources, the natural flow of the South Platte River and its tributaries, transmountain diversions and groundwater.

The South Platte River and its tributaries are the major source of natural surface supply to the study area. Monthly flows in the South Platte system vary greatly and are dependent upon the weather. The most significant factor on surface water flows is the rate of snow melt and spring rain which contribute the greatest portion of the total flow. The natural flow of the South Platte River, however, is insufficient to meet the total demand of municipal, industrial and agricultural uses. Augmentation to the basin from transmountain diversion project has been necessary to meet the growing demand.

The source of transmountain diversion water is the upper regions of the Colorado River basin. The primary transmountain diversion projects are the Moffat Tunnel System which diverts a present estimated annual yield of 60,000 acre feet through the Moffat Tunnel from the Fraser River; the Blue River system diverting into the basin through Dillon Reservoir and the Roberts Tunnel with a present annual inflow of 125,000 acre feet; and the Homestake Project which presently diverts 12,000 acre feet from the upper Colorado basin into the Arkansas River for transport to a point where it is pumped into the South Platte River near Eleven Mile Reservoir for use by the City of Aurora (2). The City of Englewood has developed a transmountain diversion system in the Ranch Creek area north of the Moffat Tunnel System of Denver which is carried through Denver's system with an interagency exchange between Denver and Englewood. A small portion of the northern part of the study area receives water from the Colorado-Big Thompson project through the Alva B. Adams tunnel owned by the Northern Colorado Water Conservancy District. Although primarily constructed for supplemental agricultural water, a number of towns in the northern part of the state have acquired and used this water in their municipal systems. The contribution of water to the study area is small with most of the service area north of the metropolitan Denver region.

The historic average annual amount of transbasin water into the study area is approximately 87,600 acre feet (3). This compared with a flow in the South Platte River at Henderson in the northern part of the study area of 251,400 acre feet per year. In a dry year, such as 1954, the South Platte flow of Henderson was 75,460 acre feet. 1954 was one of the lowest years of record in the South Platte basin above Henderson.

The primary use of transmountain water is for municipal and industrial purposes in the study area. Under the Colorado water law an importer of transmountain water has the right to successive use of the water, whereas, water originating in the basin of use can only be used once. There is at present some successive use of transmountain water by several area agencies including Denver and Aurora. Once water is discharged into the stream system, it is available for diversion by others downstream.

Groundwater is another source of water although the quantity when measured against the requirements of the area is small. According to estimates, approximately 19,000 acre feet can be drawn from groundwater by existing wells which is about 5% of the total demand. Groundwater sources include both shallow groundwater from the sand and gravel acquifers and deep groundwater from the bed rock of a confined acquifer. The use of groundwater has historically satisfied the needs of small suppliers and those not located near an available surface water source.

Regional development pressure will result in more urban competition for irrigation water. Perhaps more direct reuse will also result. There will be greater pressure for more importation of west slope water and for its subsequent reuse.

WATER QUALITY

Introduction

The purpose of this portion of the appendix is to discuss existing water quality within the study area and the interrelationships between stream basin characteristics, existing water quality, desired water quality and the probable causes for present discrepancies between existing and desired water quality. The organization of the remainder of this section is: (1) a brief description of the various stream basins within the study area, (2) presentation of the desired water quality goals for the basins, (3) a review of the existing water quality, by basin, and (4) discussion of the discrepancies noted, with suggested reasons for these discrepancies.

Basin Characteristics

The general water resource characteristics of the study area, including the major tributaries to the South Platte, water supply or flood reservoirs, and the hydrology and water supply, have been described earlier. Following are discussions of the characteristics of the major basins within the study area which bear on water quality considerations. (See Map E for stream locations.)

Cherry Creek Basin

This basin, with a drainage area of 409 square miles, extends from the southeast portion of the study area northwest to the central portion of the Denver Metropolitan area.

Above Cherry Creek Dam and Reservoir, the basin is largely undeveloped, consisting mainly of dispersed homes and farms, with minor concentrations of residential and industrial areas. Cherry Creek Reservoir is a major flood control project, providing recreational opportunities for the study area population. Discharge from the reservoir occurs only during periods of high pool elevation as a result of storm water flows received from its two main tributaries, Cherry Creek and Cottonwood Creek. Otherwise, there are prolonged periods when no flow is discharged from the reservoir to the lower portion of Cherry Creek (Reference 229).

The lower portion of Cherry Creek is principally within the City and County of Denver and traverses areas of industrial development. Crossing the creek just below the reservoir is the Highline Canal, a major irrigation canal diverting water from the South Platte and serving the eastern and northeastern portions of the study area. City Ditch, an irrigation canal, crosses Cherry Creek just prior to its confluence with the South Platte. This lower portion of Cherry Creek also passes through the city of Glendale, a small municipality surrounded by the City and County of Denver. Old sanitary landfills which have been converted to parks or shopping centers are situated adjacent to much of the lower portion of Cherry Creek (Reference 229).

The climate of the basin is basically semiarid, with intermittent rainfall and seasonal storms. The upper portion of Cherry Creek has a wide stream bed and shallow waters (Reference 259). The lower portion has been channelized in places, particularly in the section from the Denver Country Club to the creek's confluence with the South Platte (Reference 229). Stream bank vegetation is sparse; banks have been undercut; and the stream bed has become heavily silted (Reference 259).

The lower portion of Cherry Creek, passing through a rapidly urbanizing area, has the potential for experiencing nonpoint-source pollution from urban washoff, abandoned landfills and several sand and gravel pit operations. Point sources of pollution are principally effluent from the City of Glendale's sewage treatment plant and overflows from the Highline Canal (Reference 229).

The upper portion of the basin likely experiences nonpoint-source pollution from surface runoff from nonurban or agricultural land (Reference 229).

Sand Creek Basin

The Sand Creek basin consists of Sand Creek and its major tributaries: Toll Gate Creek, East and West Toll Gate creeks, Murphy Creek and Coal Creek. Sand Creek has a drainage area of approximately 183 square miles, draining the plains area to the east and south of the Denver Metropolitan area (Reference 259).

The upper portion of the basin, from the creek's source to the town of Aurora, is mostly undeveloped, passing through primarily agricultural land. Entering from the Cherry Creek Basin, the Highline Canal crosses West Toll Gate Creek, crossing again just below the confluence of East and West Toll Gate creeks. The upper portion still has a relatively undisturbed stream channel with good bank vegetation; however, the bank vegetation becomes less abundant on approaching Aurora. The stream bed near Aurora has been extensively channelized, and because the upper drainage area is mostly in the plains, with relatively low annual rainfall, streamflow is intermittent (Reference 259).

The lower portion of Sand Creek, below Aurora to the confluence with the South Platte, has been extensively channelized. Stream bank vegetation has been removed, and siltation from bank erosion is occurring. The area between Aurora and South Platte is experiencing rapid growth, with heavy industrial development taking place (Reference 229).

Flows from point sources located in the lower portion are the effluents from the Aurora and Fitzsimmons sewage treatment plants and treated industrial waste from the Refinery Corporation. In addition, the Burlington Ditch, another irrigation canal diverting water from the South Platte, crosses Sand Creek near its confluence with the South Platte and periodically contributes leakage flows to the lower portion of Sand Creek.

Agricultural runoff and some minor irrigation return flows contribute to the pollutant loads in the upper portion of Sand Creek, particularly during periods of heavy rainfall (Reference 229).

Bear Creek Basin

The Bear Creek basin, located west of the Denver Metropolitan area, consists of the area drained by Bear Creek and its major tributaries: Turkey Creek and Troublesome Creek. Bear Creek, with a drainage area of 260 square miles, flows from the Rocky Mountains to Morrison and then northeastward to its confluence with the South Platte (Reference 259).

The upper portion of Bear Creek, in the mountainous area, often experiences high rainfall, with resultant potential for flash flooding downstream. The stream bed in this portion is comprised of rock and gravel substrate and, with its steep banks and attendant vegetation cover, provides one of the better cold water fisheries in the study area. Small communities such as Evergreen and Kittredge are located in the upper portion (Reference 259).

The lower portion of Bear Creek, from Morrison to the confluence with the South Platte, has been silted because of increasing land development and resultant runoff. The proposed Carbon Dam and Reservoir is to be located in this portion. Presently, the Denver Water Board operates a large water treatment plant (Marston) in the lower portion of the creek. This plant provides approximately one-half of the potable water supply for the City of Denver. Raw water storage for the plant is provided in Marston Lake. There are also numerous diversion ditches in the lower portion, utilizing flows from Bear Creek and Turkey Creek to furnish water for Marston Lake and other water reservoirs as well as irrigation water both in and outside of Bear Creek Basin. The major diversion ditches are the Bergen, Independent Highline, Spickerman Middle, Churn, Cybler, Hindry, Lewis and Strouse, R. Lewis, Warrior, Ward, Arnett-Harriman, Hodgson, Pioneer Union and McBroom ditches (Reference 229).

The upper portion of Bear Creek presently has no major point sources of pollution. However, acid mine drainage and tunnel discharges, in addition to some nonurban agricultural runoff, contribute to the nonpoint-source potential (Reference 229).

The lower portion of the creek has as its major point source the effluent from the sewage treatment plant at Morrison. Nonpoint sources of pollution are principally urban runoff, particularly in the area south of Lakewood and just prior to Bear Creek's confluence with the South Platte, and agricultural runoff above Marston Lake. Irrigation return flows also occur, although to a lesser extent than for other nonpoint sources, primarily because of the conversion of irrigated lands into urban development and the transfer of irrigation water rights to other areas such as municipal water supply (Reference 229).

Clear Creek Basin--

The Clear Creek basin, located northwest of the Denver Metropolitan area, extends westward past the city of Golden and in addition to Clear Creek includes Ralston, Leyden, Van Bibber and Little Dry creeks.

Clear Creek has a drainage area of 247 square miles. Its headwaters originate in the Front Range of the Rocky Mountains, and the creek flows eastward to its confluence with the South Platte. The mountainous reaches of Clear Creek often experience periods of high rainfall, with a consequent potential for flash flooding throughout the basin (Reference 259).

The upper portion of the basin, extending from the Front Range to the Farmers Highline Canal just below the city of Golden, contains a great deal of undeveloped land, and stream bank vegetation is still abundant. There are also numerous diversion ditches providing water for domestic water supply, brewery and irrigation uses, both in and out of the Clear Creek basin. The major ditches are the Church, Agricultural, Croke, Farmers Highline, Lee Stewart and Eskins, Rock Mountain, Wannemaker, Slough, Cort Graves and Hughes, Ouelette, Reno and Juchem (Reference 229).

The Denver Water Board owns and operates the Moffat water treatment plant in the upper portion of Clear Creek Basin, which supplies about 40 percent of the Board's total water supply. The raw water supply is from Ralston Reservoir, at the head of Ralston Creek. This reservoir in turn is supplied by the Moffat Tunnel/Boulder Creek/South Boulder Creek Diversion Canal system (Reference 229).

The lowem portion of the Clear Creek basin is heavily developed, with the cities of Arvada, Crestview, Wheatridge and Clear Creek Valley being major residential and industrial growth areas. Urban development and agricultural uses have reduced stream bank vegetation and changed drainage patterns. Agricultural diversion ditches, principally the Swadley Logan, Manhart, Reithman, Heller, Burlington, Boyles, Fisher, Kershaw, Clear Creek and Colorado Agriculture ditches, supply irrigation waters used in this portion of the basin.

The upper portion of the basin has experienced mining activities resulting in sedimentation and acid runoff from mine tailings. The major point sources of pollution in this portion are the effluents from the Coors wastewater treatment plant and cooling waters. Agricultural withdrawals through the Farmers Highline Canal have been substantial, at times reducing stream flows in the upper portion essentially to zero. Nonpoint sources of pollution, in addition to the acid mine wastes noted, are from nonurban agricultural runoff, sand and gravel operations, and sanitary landfills (Reference 229).

The lower portion experiences point-source pollution primarily from the Clear Creek Valley, Wheatridge, Arvada and Crestview sewage treatment plants. Nonpoint sources are principally urban and agricultural runoff and some irrigation return flows (Reference 229).

South Platte River Basin--

The South Platte River basin includes the main stem of the South Platte River, from a point above Chatfield Reservoir through the metropolitan area of Denver and northeastward to the Weld County line. It consists of major portions of the Upper South Platte, Plum Creek, South Metro, Lakewood and Lower South Platte basins, with a total drainage area of approximately 581 square miles (Reference 259).

The headwaters of the South Platte River originate in the steep foothills of the Rocky Mountains; the upper portions of the river, to Chatfield Reservoir, have experienced little urban development. Upstream from Chatfield Reservoir are two major diversions: the Denver Municipal Aqueduct, conveying water for treatment to the Kassler and Marston water treatment plants; and the Highline Canal, providing irrigation water to the Cherry, Sand and lower South Platte basins. The average rainfall in the mountain areas is considerably higher than in the plains area and results in periodic flash flooding in the upper reaches.

The South Platte has been divided into two segments for the purpose of stream classification. The upper segment extends from the river's source to Exposition Avenue, and the lower segment, from Exposition Avenue to the Nebraska State line (Reference 229).

The upper portion includes Chatfield Reservoir, a flood control reservoir, and the rapidly growing towns of Littleton and Englewood, which serve as the southern boundary of the Denver Metropolitan area. Bear Creek basin flows also enter the South Platte in this upper portion. Chatfield Reservoir releases low-temperature, high-quality waters to the South Platte; however, below the reservoir, the increasing urban development has reduced stream bank vegetation, has begun to silt the river as a result of urban runoff, and has changed the temperature and flow regimes of this portion of the river (Reference 229).

The lower porton of the South Platte passes through the City and County of Denver, flowing northward past the city of Thornton, through South Adams County and the city of Brighton, to Weld County and the Nebraska State line. The City and County of Denver is heavily developed residentially, commercially and industrially, and the city of Thornton, South Adams County and Rocky Mountain Arsenal areas are developing in a like manner. Beyond the arsenal, the bas-n is still principally devoted to agriculture. Flows from the Clear Creek, Sand Creek and Cherry Creek basins also enter the South Platte in its lower portion. Sedimentation, urban runoff and the reduction of stream bank vegetation have eliminated stream pool areas, resulting in a more braided stream with less definition of channel.

Besides the municipal aqueduct and the Highline Canal mentioned pre-irrigation water for the South Platte River Basin. Major diversions in the lower portion are the City, Farmers/Gardners, Burlington (which also receives effluent from the Denver Metro sewage treatment plant), Fulton and Brantner ditches, all providing irrigation or industrial waters to the South Platte Basin (Reference 229).

The upper portion's major point sources of pollution are the sewage treatment plant effluents from Littleton and Englewood and cooling water return flow from the Arapahoe steam power plant owned by the Public Service Commission (PSC). Nonpoint pollution sources, principally below Chatfield Reservoir, stem from urban development in the Littleton/Englewood area (Reference 229).

The lower portion's point sources are the effluents from the South Lakewood, Metro, South Adams and Brighton sewage treatment plants; cooling water return flows from the PSC Zuni and Cherokee power plants; and industrial waste from Gates Rubber. Nonpoint sources are urban runoff, particularly in the City and County of Denver area; agricultural runoff downstream of 84th Avenue to Brighton; and various storm sewer overflows (Reference 229).

Big Dry Creek Basin--

Big Dry Creek, located north of the Denver Metropolitan area, has a drainage area of approximately 111 square miles, with a fairly uniform, semiarid climate and evenly distributed rainfall (Reference 259).

The upper portion, from the headwaters originating in the foothills of the Rocky Mountains to Standley Reservoir, has been suitable for cold water fishery and presently is not heavily developed. The lower portion, from Standley Reservoir to the creek's confluence with the South Platte, has constricted stream channels, low average flows resulting from low releases from Standley Reservoir, and stream bank vegetation has been removed (Reference 259).

The upper portion of the creek presently does not receive pollutants from any major point sources, and nonpoint sources are principally nonurban and agricultural runoff. There are no major agricultural diversions in this portion, irrigation waters being supplied principally from diversions in the Clear Creek basin (Reference 229).

Below Standley Reservoir, the lower portion of the creek has two point sources of pollution: sewage treatment plant effluents from Westminster and Broomfield. This portion receives nonpoint-source pollution from agricultural runoff and has several major irrigation ditches such as the German, Bull and Thompson ditches (Reference 229).

Coal Creek Basin--

Coal Creek runs northeastward from the Rocky Mountain foothills to its confluence with Boulder Creek and has a drainage area of 65 square miles. The basin has two portions: the upper, from the headwaters to the Route 93 bridge; and the lower, from the bridge to the confluence with Boulder Creek. The basin is characterized by a semiarid climate with low, intermittent rainfall and seasonal storms, particularly in the upper portion (Reference 259).

The upper portion, with abundant stream bank vegetation and a rocky bottom, has been a natural trout fishery. Although there are no major point sources of pollution in this portion, coal mining has created some nonpoint-source pollution from acid mine drainage (Reference 259).

The lower portion experiences lower flows than the upper portion, and sedimentation from agricultural nonpoint-source runoff has further degraded the stream. Point-sourceflows are the sewage treatment plant effluents from Lafayette, Louisville and Erien (Reference 139).

Boulder Creek Basin--

The Boulder Creek basin is located in the northwest portion of the study area and has approximately 366 square miles of drainage area. Its major tributaries are South Boulder Creek, entering just east of Boulder, and Coal Creek. There are two major portions: the upper, from the headwaters to Highway 119; and the lower, from Highwa- 119 to the creek's confluence with St. Vrain Creek (Reference 259).

The upper portion, to the west of Boulder, has a stable stream bed, has abundant stream bank vegetation and supports a cold water fishery. Development has not been significant, thus reducing the potential for nonpoint-source pollution (Reference 259).

The lower portion of the basin is characterized by the urban area of Boulder; the Barber Reservoir, a water supply source; and agricultural activities farther downstream. Streamflow fluctuates significantly because of dam releases; the stream bed is sandy, rather than rocky as in the upper portion; stream bank vegetation is diminished; and irrigation diversions further reduce natural streamflow (Reference 259).

The upper portion presently has no major point-source pollution inputs, nor are nonpoint sources a major pollution factor.

The basin's lower portion has point-source pollution inputs from the Boulder/White Rocks sewage treatment plant. Nonpoint sources are agricultural runoff, several sand and gravel operations between 55th Street and 75th Street, and irrigation ditch seepage. Major diversion ditches in this portion are the South Boulder Diversion, South Boulder Canyon, Community, Davidson, Marshallville and Lower Boulder ditches (Reference 229).

Desired Water Quality

During the 208 planning study, various water uses were considered and evaluated for the study area. Four broad areas of desirable use were identified: agriculture (irrigation and livestock watering), recreation (primary and secondary contact), maintenance of aquatic life (cold- and warm-water fisheries and stream or lake aesthetics) and domestic raw water supply.

Stream classifications and the requisite stream quality parameter values for these uses are indicated in Table II-A. The values shown are those used during the initial phases of the 208 Study; they will be utilized in this report both as being consistent with the available data base and as representing the latest available information. Table II-B6 indicates the classification, by reach, of the streams within the study area.

It should be noted that recently (7 December 1976) the State has considered revisions in the classification system and quality parameter values to take into account seasonal uses. The suggested changes that represent major departures from the information presented in Table II-A are as follows (Reference 259):

(1) dissolved oxygen for cold water fisheries would be raised from 6.0 to 7.0 mg/l; temperature values for cold-water fisheries would be a maximum of 20°C with 3° change; and values for warm-water fisheries, 30°C maximum with 3°C change;

(2) pollution indicators ($NH_3 + NH_4^+$, BOD_5, NO_3 and total P) were noted; values were suggested for these indicators which, al-

though not to be construed as stream standards, would point out limits beyond which environmental degradation can be expected to occur;

(3) the values for the pollution indicators in (2), above, are 5.0 mg/l for $NH_3^+ + NH_4$; 5.0 mg/l for BOD_5; 4.0 mg/l for NO_3 (as N); and for total phosphorus (as P): 0.025 mg/l for lakes and 0.1 mg/l for streams;

(4) values for total dissolved solids will not be mandatory but will be established by the Colorado Water Quality Control Commission on a case-by-case basis.

Table II-C presents historical and present uses; present State stream classification; and the latest suggested use potential and classification of the major streams in the study area. It should be recognized that the use potential represents goals for the study area consistent with the "fishable and swimmable waters" by 1983 and "zero" discharge by 1985 as mandated by the Federal Water Pollution Control Act Amendments of 1972.

Existing Water Quality

Data Sources--

The year 1972 was taken as representing the base year for flows and water quality. Flow records of the U.S. Geological Survey were examined for the following stations:

(1) in the Bear Creek basin: Morrison and Sheridan;

(2) in the Cherry Creek basin: at the confluence with the South Platte;

(3) in the Clear Creek basin: Golden and near the mouth at Derby;

(4) in the South Platte basin: Waterton, Littleton, in Denver, and Henderson.

Stream quality data were extracted from input data files of the 208 planning program's Hydrocomp model for the South Platte at Blakeland; Bear Creek at Morrison; Cherry Creek at Franktown and the Reservoir; and Clear

Creek at Golden. Similarly, data files were extracted and reviewed for diversion and point-source flows and for quality data. Finally, the Hydrocomp model outputs for maximum-minimum water quality data were reviewed for the South Platte at 38th Avenue (Reach 11) and Henderson (Reach 15); Bear Creek at its mouth near Sheridan (Reach 7); Cherry Creek at its mouth near 16th Avenue (Reach 7); Sand Creek at its mouth near Commerce City (Reach 12); and Clear Creek at its mouth near Derby (Reach 13). Additional water quality data were obtained from References 228, 259 and 209.

Table II-D indicates the wastewater treatment facilities that were investigated for their impact upon stream water quality. The first 14 were input into the Hydrocomp model, whereas the remaining six were evaluated on the basis of best available information.

Industrial facilities which were input into the Hydrocomp model include the Refinery Corporation on Sand Creek; Coors cooling waters on Clear Creek; and Gates Rubber and PSC Zuni, Arapaho and Cherokee power plants on the South Platte.

The following subsections present the existing water quality of the study area by basin. The water quality of the study area can be classified by seasonal flow characteristics, as follows:

<u>November through March--winter season</u>. Water quality during this period basically reflects a mixture of point sources, ground water and occasional additions of urban snowmelt flows. The water quality problems that occur during this period are due to concentrated urban pollutants in runoff and low temperatures suppressing natural stream cleansing mechanisms. Bacteria, BOD, oil and grease are high and DO is low.

<u>April through June--spring season</u>. High and flood runoff flows from snowmelt and frequent rainstorms maintain good water quality since most runoff source areas are in natural terrain. Sufficient flow permits flushing and dilution of point water pollution sources and nonpoint urban contaminants in spite of heavy irrigation withdrawals.

<u>July through October--summer/fall season</u>. Water users divert all available flow. Water quality is influenced by point sources, irrigation return flows and irrigation ditch seepage return and leaks since these comprise the majority of the flow.

Minor local thunderstorm (covering areas up to a few square miles) runoff of highly contaminated urban surface pollutants is usually captured by irrigation ditches. Larger runoff events and those below diversion points cause temporarily high BOD, bacteria and suspended solid loads to streams. High nutrient levels and high water temperatures cause algal growth and extreme diurnal fluctuations in water quality. This period of year generally has the worst water quality conditions.

(Reference 228)

Bear Creek Basin--

Flows at Morrison averaged approximately 20 cubic feet per second (cfs) during the winter season; 50 cfs in the spring season, with flows peaking in June near 125 cfs; and approximately 37 cfs in the summer/fall season, with occasional peaks reaching 50 cfs as a result of thunderstorm events. Diversions occurred only during the spring and summer/fall seasons, averaging approximately 36 cfs in the spring and 29 cfs in the summer/fall.

At Morrison, the temperature nearly equalled, or exceeded, the 15°C limit during the late spring and early summer (June-September). Dissolved oxygen levels ranged from a low of 8 mg/l in June, climbing steadily in the fall, to a winter level between 11 and 15 mg/l. BOD_5 showed a fairly constant level of approximately 3 mg/l throughout the year. Total dissolved solids were relatively low, showing a downward trend in the spring to about 85 mg/l, and were approximately 90 mg/l the remainder of the year. Ammonia and nitrate levels were constant at 0.13 and 0.31 mg/l, respectively. However, phosphate levels were higher than the desired level of 0.05 mg/l, being constant at 0.23 mg/l. Also, coliform and colistrep were consistently higher than suggested limits for urban irrigation. Coliforms were at the limit of 200/100 ml during the summer/fall and winter seasons and reached a peak (in April) in the summer of 1,500/100 ml. Colistrep averaged 300/100 ml during the summer/fall and winter months and reached a peak (in June) of 1,000/100 ml in the summer.

Bear Creek at its mouth showed the same general trends for temperature and dissolved oxygen as were exhibited in the upstream portions. Temperatures ranged from 3°C to 17°C in the winter, from 17°C to 25°C in the spring, and from 28°C down to 14°C in the summer/fall. There was no instance in which temperature exceeded the desired limit of 30°C. Dissolved oxygen levels for the same periods were 10.5 to 12 mg/l, 11.0 to 8.5 mg/l and 8.5 to 10 mg/l, respectively.

At the mouth, BOD_5 exhibited numerous short-duration peaks, spread fairly uniformly throughout the year, with average base levels of around 4.0 mg/l. The peaks, however, were substantial in terms of magnitude, ranging from 19 to 42 mg/l. Ammonia and nitrates also showed numerous peaks throughout the year, corresponding closely in time to the BOD_5 peaks. Base levels for ammonia and nitrates averaged approximately 0.2 and 1.0 mg/l, respectively, with peaks ranging from 0.3 to 1.8 mg/l and 2 to 6 mg/l, respectively. Phosphates showed considerably fewer peaks; however, those occurring did correspond in time with those for BOD_5, NH_3 and NO_3. The base level of PO_4 averaged 0.3 mg/l during the entire year. Those peaks thit did occur (three in the spring, one in the summer/fall and one in the winter) ranged from 0.7 to 2.3 mg/l. TDS level fluctuations corresponded more closely with NH_3 than the other parameters discussed above. Base levels averaged approximately 220 mg/l, with peaks ranging from 1,100 to 3,800 mg/l.

Coliform and colistrep values were consistently higher than suggested values. They again followed the general time pattern of NH_3 and TDS, with base levels of approximately 300 and 700/100 ml, respectively. However, both exhibited sustained high levels in the winter months of November and December. Peak values for coliform and colistrep ranged from 1,000 to 12,500/100 ml and 1,000 to 154,000/100 ml, respectively.

Cherry Creek Basin--

There are no available streamflow records for Cherry Creek above Cherry Creek Reservoir. At the mouth, flows averaged approximately 12.5 cfs during the winter, 17.5 cfs during the spring and 15 cfs during the summer/fall season. Flow peaks were noted in April (30 and 85 cfs); May (35 cfs); June (90 and 50 cfs); August (30, 33 and 83 cfs); September (63 cfs); and November (45 cfs).

Water quality above the reservoir at Franktown showed temperatures ranging from 1°C to 4°C in the winter; 5°C to 16°C in the spring; and 30°C down to 10°C in the summer/fall. Dissolved oxygen during the same seasons ranged from 12 to 14 mg/l; 11 down to 9 mg/l; and 9 to 11 mg/l, respectively. BOD_5 levels were 2 mg/l during the winter, 1.3 mg/l during the spring and 3 mg/l during the summer/fall. TDS levels were constant at 250 mg/l during the summer/fall and winter seasons, dropping to about 75 mg/l during the spring. None of these parameters approached the suggested limits for the stream classification assigned to upper Cherry Creek.

Ammonia and nitrates showed a trend upward from winter values during the spring and summer/fall. Winter, spring and summer/fall values for NH_3 were 0.01, 0.02, and from 0.07 to 0.10 mg/l, respectively, while NO_3 levels for the same periods were approximately 0.11, 0.15 and 0.18 mg/l, respectively. Phosphates showed the same general tendency to increase during late spring and summer/fall, ranging from 0.01 mg/l in winter to 0.06 mg/l in the late spring, then falling off to 0.03 mg/l by the end of the fall. Both NH_3 and NO_3 were well below the suggested limits for upper Cherry Creek; however, from June through October (late spring through the fall), PO_4 exceeded limits suggested for lake aesthetics (0.025 mg/l). Phosphate levels never approached the levels suggested for raw water supply (0.1 mg/l). No coliform or colistrep data are available for the upper portion of Cherry Creek.

In addition to flows released from the reservoir, Cherry Creek water quantity below the reservoir was augmented by inflows from the City Ditch and the Highline Canal. From April through October, the City Ditch contributed 3 cfs, whereas during the spring (April through June) and in midsummer (August) the Highline Canal contributed an average of approximately 1.5 cfs, with short-duration peaks up to 3 cfs.

The lower portion of Cherry Creek (below the reservoir) showed winter temperatures of 2°C to 18°C, spring values of 16°C to 25°C and summer/fall values of 26°C down to 15°C. Dissolved oxygen levels during the same time periods were 8.5 to 12 mg/l, 6.5 to 9.5 mg/l and 6 to 10 mg/l, respectively. TDS levels, again for the same time periods, averaged approximately 480, 650 and 725 mg/l, respectively. However, in each month of the year, there were numerous peak values, ranging from 1,100 to 7,100 mg/l. BOD_5 had a base value of approximately 3 mg/l but showed numerous high peaks, corresponding in time with TDS peaks and ranging mostly from 12 to 45 mg/l with some as high as 80 mg/l. The TDS values on an average were within suggested limits for urban irrigation, while dissolved oxgyen was always above the suggested 5 mg/l level.

Ammonia, nitrates and phosphates, showing the same time correlation in their peaks with BOD_5 and TDS but having fewer peaks, showed slightly higher base values in winter than in the spring and summer/fall seasons. Base values for ammonia in the winter were approximately 1.0 mg/l, while in the spring and summer/fall they dropped to approximately 0.6 mg/l, with peak values during the same time periods ranging from 2.5 to 3.5 mg/l and 1.9 to 4.2 mg/l. Nitrates showed the same trend: winter base values of approximately 3.0 mg/l dropped to 2.0 mg/l in the spring and summer/fall. Peak values ranged from 4 to 5 mg/l in the winter and from 3 to 5.5 mg/l in the spring and summer/fall. Winter phosphate levels averaged about 4 mg/l, with peaks ranging from 4.5 to 7 mg/l, while spring and summer/fall values averaged 2.5 mg/l, with peaks ranging from 4.5 to 6 mg/l. Phosphate levels were consistently appreciably higher than the suggested 0.5 mg/l level, whereas ammonia and nitrate were lower than their limits of 4 and 10 mg/l, respectively.

Coliform and colistrep exhibited the same peaking times as the previously mentioned parameters. However, unlike colistrep, coliforms showed higher base levels in spring and summer/fall than in winter. The winter base level for coliform was approximately 650/100 ml, with peaks ranging from 1,000 to 26,000/100 ml, whereas for the spring and summer/fall the base level was approximately 800/100 ml, with peaks ranging from 1,000 to 23,000/100 ml. Colistrep winter base values were 1,800/100 ml, with peaks ranging from 8,100 to 204,000/100 ml. The base level for the spring and summer/fall seasons was approximately 1,000/100 ml. Coliform levels, on the average base level, would be meeting suggested levels (1,000/100 ml for secondary contact) consistently only in the winter, whereas colistrep was extremely far above its suggested limit of 20/100 ml.

Sand Creek Basin—

Sand Creek flows are intermittent during the winter and at certain times of the year are nonexistent, particularly in the upper portion. Sewage flows from the Aurora and Fitzsimmons treatment plants and Metro flows from the Burlington ditch contribute to the lower portion's base flow of approximately 5 to 10 cfs.

Water quality at the mouth shows the influence of these sources. Winter temperatures ranged from 6°C to 15°C, spring from 15°C to 25°C and summer/fall from 26°C down to 15°C. Dissolved oxygen winter values were constant at 12 mg/l, spring from 11 down to 8.5 mg/l and summer/fall from 8.5 to 10 mg/l. Both temperature and dissolved oxygen were within their suggested limits. TDS winter values were approximately 900 mg/l; spring values, 1,500 mg/l; and summer/fall values, 1,200 mg/l. These values exceeded, on the average, suggested levels for urban irrigation.

BOD_5 and the nutrient ammonia (NH_3) indicate somewhat lower levels in early summer/fall than during other periods. Winter values for BOD_5 showed a base level of 9 mg/l, with peaks ranging from 14 to 43 mg/l; spring base levels of 10 mg/l, with peaks of 12 to 38 mg/l; and summer/fall base levels of 6 mg/l, with peaks of 14 to 35 mg/l. Likewise, NH_3 showed winter base levels of approximately 5 mg/l ranging up to 7 mg/l; spring base levels of 5 mg/l, with a range of 1 to 6 mg/l; and summer base levels of 3 mg/l, ranging up to 6.5 mg/l in late fall (October). Nitrate winter levels were 3 mg/l, trending upward in spring and summer/fall to about 3.5 mg/l. There were noticeable drops in NO_3 levels in June and again in August to about 1.5 to 2 mg/l. Otherwise, the seasonal base levels mentioned earlier were relatively constant. Phosphate showed a fairly constant base level of 3.5 mg/l for all seasons but dropped noticeably in June and again in August to around 2 mg/l. Two high peak values were noted: one in early September, to 8.5 mg/l, and another in late December, to 4.5 mg/l. It should also be noted that BOD_5 and NH_3 showed numerous peaks throughout the year, whereas NO_3 and PO_4 values

values were relatively constant, with the exceptions noted. Only NO_3 was consistently below its suggested limit, while PO_4 was consistently much higher than its suggested level. Ammonia was below its suggested level of 4 mg/l only during the summer (June-August).

Coliform and colistrep levels varied widely throughout the year but showed average values of approximately 2,500 and 4,000/100 ml, respectively. Coliforms ranged from 360 to 19,000/100 ml, while colistrep ranged from 1,000 to 123,000/100 ml.

Clear Creek Basin--

Clear Creek flows at Golden averaged 50 cfs during the winter, with high flows from snowmelt runoff occurring in late spring (early spring flows ranged from 75 cfs in April to 600 cfs in May).

June flows peaked in early June at 1,300 cfs and dropped to 500 cfs by the end of the month. Flows continued to drop in early summer (July) to 125 cfs and then stayed at that level through the summer. Fall saw a drop from mid-September through October to 60 cfs.

Temperature during the winter ranged from 0°C to 10°C; in spring from 5°C to 13°C; and in summer/fall from 13°C down to 9°C, peaking in August at 20°C. Dissolved oxygen ranged during the same seasons from 6 to 15 mg/l; 6 to 8 mg/l; and 9 to 12 mg/l, respectively. TDS levels were constant at 200 mg/l except for peaks of 500 mg/l in early June and early December.

BOD_5 levels were constant at 2 mg/l except for peaks of 5 mg/l in late April and in late October and of 3 mg/l in May and November. Nutrients (NH_3, NO_3 and PO_4) were constant at 0.23, 0.4 and 0.2 mg/l, respectively. Phosphate was the only parameter which did not meet its suggested limit.

Coliform levels were fairly constant throughout the year at 204/100 ml with the exception of higher levels (400 to 600/100 ml) in the latter portions of the months of April, May, October and November and lower levels (10 to 90/100 ml) in the early portions of the same months. Colistrep levels were fairly constant at 300/100 ml except for low levels

(30/100 ml) in early May and November. Coliform levels marginally met the suggested limit (200/100 ml) for primary-contact recreation, while colistrep was significantly higher than its suggested limit of 20/100 ml.

Below Golden, the major diversions discussed earlier removed an average of 50 cfs of winter flow, 270 cfs in the spring and 211 cfs in the summer/fall season. Obviously, since these are the averages of monthly average diversion flows, the monthly flow variations were sizeable, and the flows were diverted only when there were flows within the basin to divert.

Flows at the mouth of Clear Creek showed the influence of the diversions mentioned above. Winter flows averaged approximately 40 cfs but showed a peak flow in early November of 150 cfs. Early spring flows (April and May), although averaging 50 cfs, showed peaks in late April and May of about 150 cfs. June flows peaked at 850 cfs aud ranged from 275 cfs at the beginning of the month to 100 cfs at the end of the month. Summer/fall flows averaged approximately 20 cfs, with peak flows in late August and early September up to about 175 cfs.

Stream temperature at the mouth rose consistently from a winter level of 5°C to 15°C, to 20°C in the spring; and to 25°C in summer/fall. Dissolved oxygen was at a high of 12 mg/l during the winter, falling in the spring to 8.5 mg/l and staying at that level during the summer before rising again during the fall to 12 mg/l. TDS levels remained relatively constant at 400 mg/l except for winter peaks in early February, late March and late December of 3,000, 4,000 and 2,400 mg/l, respectively. Both temperature and dissolved oxygen consistently met their suggested limits, as did TDS, except for the peak values noted.

BOD_5 and nutrients (NH_3, NO_3 and PO_4) showed definite and pronounced trends of higher levels with more peaks in late winter, and lower levels in late spring and summer/fall with fewer, less pronounced peaks. BOD_5 winter base levels ranged from 16 to 23 mg/l, with peaks ranging from 31 to 50 mg/l. Spring base levels fell from 12 to 4 mg/l, with only one peak, of 15 mg/l, whereas summer/fall base levels were from 4 to 8 mg/l, with early summer peaks of 12 mg/l. Ammonia showed winter base levels from 2.5 to 4 mg/l, with late winter peaks ranging from 7 to 11 mg/l. Spring levels dropped from 4 to 0.5 mg/l, rising slightly to 1 mg/l for a summer base level, with no peak values. Nitrate winter levels were approximately 2.5 to 4 mg/l in early spring, falling to 1 mg/l by the beginning of summer. Early summer values were 1 mg/l and rose steadily to 2 mg/l by November (early winter). Phosphate levels fluctuated significantly, base levels ranging from 2.5 to 3.3 mg/l in winter, with peaks in December and March of 5 and 4.8 mg/l, respectively. Spring levels fell from 3 to 1 mg/l, while summer/fall levels ranged from 0 to 2 mg/l. Ammonia and nitrate levels were within suggested limits, while phosphate was significantly higher than its limit.

Coliform and colistrep levels fluctuated significantly, with base levels of 800 and 300/100 ml, respectively. Numerous peaks throughout the year occurred for both parameters, with coliform peaks as high as 25,000/100 ml (March) and colistrep peaks as high as 200,000/100 ml (March).

South Platte River Basin--

Flows upstream from Chatfield Reservoir showed a winter range of approximately 25 cfs. Spring and early summer flows showed wide variations in flow, with numerous peaks. Srping flows ranged from average monthly flows in April, May and June of 75, 150 and 300 cfs, respectively, with peak flows in the same months of 250, 300 and 575. Early summer flows (July and August) showed average monthly flows of 250 and 175 cfs, with peaks of 400 and 350 cfs. Late summer and fall flows remained fairly constant at 50 cfs.

Below Chatfield Reservoir at Littleton, the flow pattern was the same but with higher monthly average and peak flows. Winter flows were approximately 50 cfs, with spring (April, May and June) monthly averages of 100, 175 and 325 cfs, respectively. Peak flows were 180, 325 and 730 cfs. Early summer (July and August) average flows were 250 and 175 cfs, with peaks of 400 and 350 cfs, respectively. Late summer and fall flows were fairly constant at 50 cfs.

Water quality levels at Blakeland (just above Littleton) showed high-quality water being released from the reservoir. Temperature ranged in the winter from 2°C to 12°C; in the spring from 14°C to 18°C; and in summer/fall from 18°C up to 20°C and back down to 12°C. Dissolved oxygen ranged during the same seasons from 9 to 10 mg/l; from 8 down to 6 mg/l; and from 6 back to 8 mg/l. TDS and BOD_5 levels were constant at 250 and 5 mg/l. All of these parameters were within their suggested limits except during the summer, when temperature exceeded its limit of 15°C during June through September.

Ammonia, nitrate and phosphate levels were 0.01, 0.03 and 0.05 mg/l, respectively, all equal to or less than their suggested limits.

Coliform levels were less than 40/100 ml throughout the year, less than the suggested limit of 200/100 ml. However, colistrep, although never higher than 45/100 ml, was only below its suggested limit of 20/100 ml during late April and October.

From Blakeland to 38th Avenue in Denver (Reach 11), diversion flows averaged 47 cfs during the spring, 51 cfs during summer/fall and 25 cfs during the winter.

Winter temperature at 38th Avenue ranged from 4°C to 15°C; in spring, from 15°C to 24°C; and in summer/fall, from 26°C back down to 15°C. Dissolved oxygen during the same seasons ranged from 10 to 12 mg/l; 10 to 7.5 mg/l; and 7.5 to 9 mg/l. TDS base levels, again during these seasons, were 500, 600 and 700 mg/l, with peak values of 4,500, 5,000 and 4,600 mg/l, respectively. TDS levels showed extreme, pronounced peaks, particularly in the winter and early spring, with two peaks in the summer/fall, one in August and the other in October.

BOD_5 levels did not showed pronounced peaks at any time during the year. Winter levels ranged from 11 to 17 mg/l, whereas spring and summer/fall levels ranged from 18 down to 7 mg/l and from 7 back up to 14 mg/l. Ammonia, nitrate and phosphate levels all showed a tendency to decrease in late spring and early summer from previous winter levels. Winter, spring and summer/fall levels for NH_3 were 3 mg/l; 3 mg/l down to 1 mg/l; and 1 mg/l back up to 3 mg/l, respectively. Likewise, NO_3 levels were 1.3 to 1.8 mg/l; 1.8 down to 1 mg/l; and 1 back up to 2.5 mg/l. There were several NO_3 peaks throughout the year, particularly in the late spring-early summer months, ranging from 2.5 to 4 mg/l. Phosphate base levels in winter, spring and summer/fall were 2, 1 and 1.5 mg/l, respectively, with peaks ranging from 1.5 to 4 mg/l.

Coliform base levels approximated 600/100 ml throughout the year, with numerous peaks ranging from 5,000 to 21,000/100 ml. Colistrep base levels increased from winter to spring and summer/fall (20,000 to 35,000/100 ml). Although less numerous than coliform, peaks for colistrep ranged from 55,000 to 160,000/100 ml.

Diversion flows below 38th Avenue to Henderson averaged 80 cfs during the winter, 260 cfs in the spring and 180 cfs in the summer/fall. Henderson was the limit of the Hydrocomp model for the South Platte Main Stem (Reach 11).

Temperatures in the South Platte at Henderson ranged from 5°C to 16°C during the winter; from 18°C to 23°C during the spring; and from 24°C back to 16°C in summer/fall. Dissolved oxygen during the same seasons ranged from 9.5 to 11 mg/l; 9 to 7.5 mg/l; and 7 to 8.5 mg/l. TDS showed a base level of approximately 700 mg/l throughout the year, with several peaks corresponding to those in Reach 11 and ranging from 1,800 to 4,000 mg/l.

BOD_5 showed a more pronounced trend to reduced levels during the spring and early summer than in Reach 11. Winter levels ranged from 25 to 35 mg/l, while spring and summer/fall levels ranged from 20 down to 10 mg/l and 10 up again to 25 mg/l, respectively. This more pronounced trend, in comparison with Reach 11, was also true for NH_3 and PO_4 but not for NO_3. Ammonia winter levels were about 10 mg/l, while spring levels ranged from 12.5 down to 4 mg/l, and summer/fall levels increased from 6 to 11.5 mg/l. Nitrate levels ranged in the winter from 1.5 to 2.3 mg/l; in the spring from 2.7 down to 1 mg/l; and in summer/fall from 1.7 up to 2.5 mg/l. Phosphate range during the same seasons was from 4.5 to 6 mg/l; from 6 down to 1 mg/l; and from 3 up to 6 mg/l. Neither ammonia nor phosphate was within or less than its suggested limit.

Coliform levels had a base level throughout the year of approximately 1,000/100 ml, with numerous peaks ranging from 1,700 to 16,000/100 ml. Colistrep had a base level of 2,500/100 ml, with peaks ranging from 25,000 to 125,000/100 ml. Colistrep was extremely far above its suggested limit, while coliform, although meeting the 1,000/100 ml suggested limit on a base level, had numerous periods throughout the year that were far above that limit.

The information on existing water quality for the basins presented previously is summarized in Table II-E.

Big Dry, Coal and Boulder Creek Basins--

There are no significant existing data for these basins available for assessment of seasonal variations in water quality, nor are there sizeable amounts of data for assessment of nonpoint- or point-source water quality.

Water quality for Boulddr Creek at its mouth (confluence with St. Vrain Creek) indicated an arithmetic mean of samples taken 7 to 12 September 1971 for BOD_5 of 2.8 mg/l, total dissolved solids of 955 mg/l, fecal coliform of 1,080 MPN/100 ml and fecal streptococcus of 14,500 MPN/100 ml (Reference 209). It has also been noted that below the Boulder/White Rocks treatment plant chlorine and ammonia residuals preclude the migration farther upstream of sensitive fish species; fecal coliform and fecal streptococcus counts increase from upstream levels; and dissolved oxygen falls to a range of 6 to 8 mg/l from upstream levels of 9 to 13 mg/l (Reference 259). The headwaters of Boulder Creek were noted to have high levels of dissolved oxygen and temperatures from November through March of 5°C (Reference 259). It has also been noted that phosphate levels are apparently higher than suggested levels for stream aesthetics (0.05 mg/l) (Reference 228).

Coal Creek, in the upper portion of its basin, has low temperatures and dissolved oxygen levels sufficient to support a put-and-take trout fishery (Reference 259). The lower portion's water quality is degraded, because of discharges from the Erie, Lafayette and Louisville municipal treatment plants and the extraction of coal, and shows levels of fecal coliform and fecal streptococcus greater than 200 MPN/100 ml (Reference 228).

Water quality in the upper portion of Big Dry Creek basin is presently unaffected by point sources of pollution and has been suitable for use as a cold water fishery (Reference 259). It appears that levels of phosphate and total nitrogen are lower than suggested levels for stream aesthetics (Reference 228). In thx lower portion, water quality is impacted by low releases from Standley Reservoir and point-source inflows from the Westminster and Broomfield municipal wastewater treatment plants. Coliform levels periodically exceed suggested levels for urban irrigation and secondary-contact recreation.

Water Quality Problems

This section will discuss the general and specific basin water quality problems for basins in the study area and will present an assessment of the relative significance of point versus nonpoint sources and their contribution to water quality problems.

Basin Water Quality Trends--

At the upstream portions of the South Platte (Blakeland), Bear (Morrison) and Clear (Golden) basins, suggested levels for fecal coliform are met only in the summer/fall and winter seasons. Otherwise, both fecal coliform and fecal streptococcus limits are exceeded throughout the basins for primary and secondary recreation and for urban irrigation.

In the Sand and Clear Creek basins, as well as in the South Platte River Basin from Littleton to Henderson, ammonia concentrations (in conjunction with pH and temperature) are on the average at potentially toxic levels throughout the year, particularly in the South Platte. Ammonia appears at toxic levels in the Cherry Creek basin only during the spring. Phosphate levels are exceeded in all basins throughout the year, particularly below the headwaters.

With the exception of ammonia and phosphate, overall water quality is better during the winter, declining in quality through the spring to the summer/fall season. Ammonia and phosphate levels appear to be at their worst during the spring season.

With the exception of Sand Creek, levels for total dissolved solids are at or below suggested specific water uses. Although there does not appear to be any noticeable seasonal trend, there is a definite and pronounced tendency for TDS levels to increase significantly from upstream to downstream within each basin.

Temperature and dissolved oxygen appear to be adequate for their respective suggested levels for all basins throughout the year. Temperature effects upon dissolved oxygen appear more pronounced in the basins tributary to the South Platte than in the South Platte itself. BOD_5 shows definite tendencies to increase from upstream to downstream in all basins, with levels generally higher in the winter than in other seasons, particularly in the South Platte.

Point- and Nonpoint-Source Contributions--

Major point sources were identified by basin in Table II-D, presented earlier. On the whole, the municipal treatment plants do not appear to have a significant impact upon dissolved oxygen, total dissolved solids, fecal coliforms or fecal streptococci. However, the Englewood, Littleton, South Lakewood and Metro sewage treatment plants discharge to the South Platte River and are contributing BOD_5, ammonia and phosphate loads which are likely to be substantial in terms of their impact upon water quality. BOD_5 values range from 20 to 90 mg/l, averaging approximately 35 mg/l; ammonia levels are approximately 15 mg/l; and phosphates range from 8 to 10 mg/l.

The Glendale plant on Cherry Creek contributes significantly to the base flow of the creek. However, effluent ammonia and BOD_5 levels are relatively low (5 and 12 mg/l, respectively), but TDS, PO_4 and fecal coliforms in the effluent are apparently contributing to water quality problems at the mouth (the effluent levels are 1,070 mg/l, 18 mg/l and 1,340 MPN/100 ml, respectively).

Levels of TDS (approximately 900 mg/l), ammonia (10 mg/l) and phosphate (8 mg/l) from the Aurora sewage treatment effluent disposed to Sand

Creek is contributing to that creek's water quality problems. In addition, effluent dissolved oxygen levels of approximately 4.6 mg/l are impairing stream water quality.

Ammonia and phosphate levels for the municipal effluents going to Clear Creek, with the exception of Coors, are approximately 12 and 8 mg/l, respectively. The Coors wastewater effluent is high in BOD_5, particularly during the late spring and summer seasons, ranging from 95 to 135 mg/l.

To indicate the general, estimated contribution of point- versus nonpoint-source loads to the South Platte and the major tributaries within the study area, Table II-F was developed, utilizing information from the input files of the Hydrocomp model for the year 1972 and also Reference 260. For the study area as a whole, existing conditions indicate that point sources are significant in terms of BOD_5, ammonia and phosphate. However, the significant impacts are noticeable principally for Clear Creek, where the Coors wastewater treatment plant is by far the largest loading source; the South Metro portion of the South Platte Basin, where Englewood is the most significant point source; and the lower South Platte, where the Metro plant is by far the most significant point source. It might be noted that if these three plants were to average 30 mg/l BOD_5 in their effluents, rather than their existing levels, BOD_5 point-source loading in Clear Creek would be reduced to 2,210 pounds per day; South Metro point-source loads, to 3,400 pounds per day; and the lower South Platte, to 27,100 pounds per day. Thus it appears that attaining secondary treatment for these major contributors of BOD_5 loads would have a significant positive influence only in the Clear Creek basin. Also, it is likely that reductions in point-source loadings for ammonia and phosphates would occur only with treatment levels significantly higher than those presently practiced. Point-source loadings for total dissolved solids are only approximately 25 percent of the total loads within the study area, and are significant only in the lower South Platte. It is therefore unlikely that the improvement in TDS removals for point sources will have any noticeable impact within the study area. Table II-F also indicates that nonpoint sources of fecal coliform and

BIOLOGY

The Metropolitan Denver region is part of the high plains area that extends from the Great Plains to the foothills of the Rocky Mountains. The elevation of the study area ranges from 1,394 m [4,600 ft] to 2,424 m [8,000 ft], placing it within the Upper Sonoran life zone 1,061 m [3,500 ft] to 1,667 m [5,500 ft] and the transition life zone 1,667 m [5,500 ft] to 2,424 m [8,000 ft] (Reference 24). The growth and distribution of vegetation is largely dependent upon climate, relief, substrata, fire and the occurence of human activities such as grazing and agriculture. With an average annual precipitation rate of only 30 to 40 cm [12 to 16 in], water availability is the chief limiting factor leading to the low growth of grasses and forbs on the plains.

Biotic Communities

Prior to settlement, the plains supported a mixed prairie which was made up primarily of perennial bunchgrasses. Short grasses such as blue grama and buffalo grass dominated on drier sites. Taller grasses (western wheatgrass and little bluestem) occurred on sites with higher moisture, such as along eastern stream courses and toward the mountains to the west. Prior to settlement, a very complex mosaic of steppe communities existed in the Denver area in response to the numerous soils (Reference 9). Under natural conditions, the three major plant communities probably were (1) upland prairie or short-grass plains, (2) meadow and (3) cottonwood-willow. The plains did not support tree growth except along the watercourses, which were fringed with cottonwoods and willows. Dense thickets of wild plum and chokecherry, with scattered clumps of hackberry and box elder, occurred sometimes in gulches and arroyos (Reference 718).

Large grazing animals such as bison, antelope elk and deer roamed throughout the plains region, while prairie dogs formed extensive colonies in the upland prairie.

Human activities, mainly in the form of cultivation, livestock grazing, and urbanization have altered the natural vegetation and habitats considerably. Sixty-five percent of Adams County is currently under cultivation, and 35 percent of Arapahoe County is similarly utilized.

The remaining uncultivated lands are generally used for pasture and range or for urban and residential purposes (References 701, 702). The Denver Metropolitan area represents a radically altered environment. The extensive introduction of non-native trees, shrubs, herbs and grasses has created an urban ecosystem in Denver that did not exist before settlement. Wildlife species tolerant to human presence predominate in these areas. Several introduced bird and rodent species have proliferated to the extent that they have displaced the native wildlife species. Urbanization, to a great extent, has removed many wildlife habitat areas.

The present biotic communities can be classified according to the following general units: (1) Cultivated Lands, (2) Uplands Vegetation, (3) Riparian and Aquatic, (4) Forest and Brushland and (5) Residential/ Urban. A comparison of these major biotic communities, with their characteristic plant and animal associations, is shown in Appendix Table A-4.

APPENDIX TABLE A-4 SUMMARY OF BIOTIC COMMUNITY CHARACTERISTICS, METROPOLITAN DENVER AREA

Unit	Location and examples	Characteristic vegetation	Characteristic birds	Characteristic animals
Cultivated Lands	Flat or rolling farmlands; east and north of Denver. Major portions of Weld and Adams counties.	Alfalfa, corn, sugar beet, vegetables, wheat, oats, barley, rye, forage sorghum.	Brewer's blackbird, western vesper sparrow, ring-necked pheasant, western meadowlark, lark bunting.	Meadow vole, pocket gopher, ground squirrel, harvest mouse, western jumping mouse, weasel, bullsnake, garter snake.
	Rural dwellings; farm buildings.	Sunflower, prickly lettuce, Russian thistle, tansy mustard, dandelion, garden escapes.	Barn swallow, Say's phoebe, housefinch.	House mouse, raccoon, feral cat, spadefoot toad, garter snake.
	Steep dirt banks; along ditches and seasonal streams.		Bank swallow, kingfisher.	Fence lizard.
Uplands Vegetation	Arid plains region; typically found in eastern Adams and Arapahoe counties.	Blue grama grass, buffalo grass, western wheatgrass, little bluestem, Junegrass, needle-and-thread, red three-awn, locoweed, sunflower, aster, fanweed, prickly pear, plantain, yucca.	Burrowing, owl, desert horned lark, mountain plover, turkey vulture, red-tailed hawk.	Jackrabbit, prairie vole, pocket mouse, Ord kangaroo rat, coyote, pronghorn antelope, prairie rattlesnake, bullsnake, central plains milksnake, sagebrush lizard, horned lizard.
	Bluffs and cliffs.		Cliff swallow, prairie falcon, ferruginous roughleg hawk.	

APPENDIX TABLE A-4 SUMMARY OF BIOTIC COMMUNITY CHARACTERISTICS, METROPOLITAN DENVER AREA (continued)

Unit	Location and examples	Characteristic vegetation	Characteristic birds	Characteristic animals
Riparian and Aquatic	Cottonwoods; along rivers and streams such as South Platte River and Cherry Creek.	Plains cottonwood, box elder, willow, narrow leaf cottonwood.	Red-headed woodpecker, Rocky Mountain screech owl, Swainson's hawk, crow, Bullock's oriole, kingbird, western mockingbird, white-rumped shrike.	Raccoon, fox squirrel, shrew, weasel, bat, barred tiger salamander, yellowbellied racer, gerter snake.
	Shrubbery; along streams and creeks and intermittently between stretches of cottonwood.	Chokecherry, wild plum, buffaloberry, hawthorn, rabbitbrush, willow.	Black-headed grosbeak, cat bird, brown thrasher, yellow warbler, song sparrow.	Striped skunk, raccoon, eastern woodrat, deer mouse, yellow-bellied racer, garter snake.
	Lakes and ponds; storage reservoirs such as Barr Lake and ponds throughout farming region and urban areas.	Willow, rushes, cattail, sedge, salt grass and aquatic plants.	Grebe, gull, tern, goose, green heron, mallard, pintail, shoveler and other ducks, shorebirds.	Snapping turtle, box turtle, boreal chorus frog, carp, brown trout, chub, minnow, shiner, catfish.
	Marsh areas and swamps; along the floodplain of South Platte River.	Salt grass, bulrush and other rushes, sedge.	Rail, coot, heron, bittern, duck, red-winged blackbird, yellowthroat.	Muskrat, coyote, bullfrog, leopard frog, boreal chorus frog, garter snake, northern water-snake.
Forest and Brush-lands	Lower tablelands; gently rising plains area west of Denver. Eastern portions of Jefferson and Boulder counties.	Scrub oak, choke cherry, mule's ears, wild plum, juneberry.	Virginia's warbler, woodhouse's jay, spurred towhee, poorwill, rock wren.	Mule deer, jackrabbit, gray fox, mountain cottontail, Richardson's ground squirrel.

APPENDIX TABLE A-4 SUMMARY OF BIOTIC COMMUNITY CHARACTERISTICS, METROPOLITAN DENVER AREA (continued)

Unit	Location and examples	Characteristic vegetation	Characteristic birds	Characteristic animals
	Higher tablelands and foothills; mesa areas, hogbacks and lower slopes of Front Range. Foothills south of Denver.	Ponderosa pine, Douglas fir, Rocky Mountain juniper, bear-berry, wax currant, thimble-berry.	Long-crested jay, Lewis woodpecker, Natalie's sapsucker, green-tailed towhee, plum-beous vireo, pigmy nuthatch, mountain chickadee, chestnut-backed bluebird.	Pine squirrel, yellow-bellied marmot, American elk, mule deer, bobcat, badger.
	Canyons and Cliffs; Clear Creek Canyon, Bear Creek Canyon, Boulder Creek Canyon and other small canyons and facing cliffs along Front Range.	Narrow-leafed cotton-wood, Colorado blue spruce, mountain ash, common juniper, smooth sumac, wild plum.	Golden eagle, canyon wren, cliff swallow, white-throated swift.	Deer mice, woodrats, Colo-rado chipmunk, raccoon, striped skunk.
Urban/Re-sident-ial	Greater Denver Metro-politan area; in-cludes residential environs, City parks and other recreational faci-lities.	Ornamental shrubs, flow-ers, lawn-type grasses, soft maple, elm, weep-ing willow, Carolina and Lombardy poplar, ash sycamore, Norway pine, Russian olive, and several varieties of fruit trees.	Robin, starling, mockingbird, house sparrow, black-capped chickadee, chipping sparrow, rock dove, red-eyed vireo, bronzed grackle.	House mouse, Norway rat pocket gopher, feral cat.

Source: References 28, 29, 30, 31, 32 and 33.

Significant biological features of the Denver area are shown on Map F. A comparison of sensitive environmental habitats, as indicated on the map and their associated wildlife communities is given in Appendix Table A-5.

Appendix Table A-5. SIGNIFICANT ENVIRONMENTAL HABITATS AND ASSOCIATIONS

Habitat Areas	Wildlife Associations
Water-Associated Features	
Riparian corridors—unchannelized marshes, stream meanders ponds, lakes and reservoirs	Waterfowl and shorebirds, warm-water fisheries, cold-water fisheries (deep reservoirs), heron rookeries.
Riparian corridors--channelized and gravel pit pond areas	Supplementary or marginal waterfowl areas, warm-water fisheries.
Cottonwood-willow groves	Heron rookery, resident and migrant bird refuge, grazing animal resting area.
Terrestrial Features	
Prairie grassland (i.e. Rocky Mountain Arsenal, Johns-Manville Ken Caryl Ranch)	Prairie-dog towns associated with rare blackfooted ferret, antelope rangeland
Forest and brushland	Winter-feeding areas for mule deer, elk and bighorn sheep, peregrine falcon feeding range.

Rare and Endangered Species

The Federal Register for rare or endangered plant species was reviewed for the State of Colorado (Reference 614). No plant species were considered to be threatened in the Denver Region.

The Nongame and Endangered Species Conservation Act (Reference 968) for the state of Colorado is consistent with Title 50, Part 17 of the U.S. Conservation of Endangered Species Act. The Colorado Division of Wildlife further protects several wildlife species not covered by the Federal Conservation Act. The Wildlife Division has recognized the stress on wildlife caused by a growing population and changing land use, and endeavors to protect wildlife habitat as well as endangered wildlife species. Animals protected by State and Federal regulations (Reference 614) that may occur within the study area include the black-footed ferret, peregrine falcon, white pelican and river otter.

The historic range of the black-footed ferret coincides closely with that of its prey species the prairie dog. Thus the changing prairie habitat and, indirectly, prairie dog control programs have strongly affected the black-footed ferret. Peregrine falcons occasionally have been observed in the mountainous forest and brushland areas. The Denver plains area may have some value as a feeding range for this species. Within Colorado, the white pelican is considered endangered as a nesting summer resident. While pelicans may be found at several reservoirs along the South Platte River drainage; however, they nest only at Riverside Reservoir, outside the study area. River otters are generally rare in Colorado and are intolerant of human presence. Scattered sightings have been reported along the South Platte River drainage in Weld County (Reference 969).

ENERGY

This discussion of current conditions for sources and uses of energy in the study area is based essentially on the report "Future Energy Alternatives for Colorado" (Reference 970). The use of a statewide report for this regional analysis is possible for two reasons: The 1975 population of the study area is 57 percent of the state population; and significant departures in trends, either statewide or in the study area, are not expected. Sources and uses of energy for and by the industrial sector of the study area may be somewhat understated in the report because that proportion of the state's industry which is lōcated in the study area is probably higher than represented by the population comparison.

The 1972 pattern of consumption of energy sources is shown in Appendix Table A- 6 . This table shows, for example, that petroleum products supplied about 42 percent of the energy used in the Denver Metro area and that over 70 percent of that energy source was consumed by the transportation sector. Although coal supplied only 17 percent of the total energy, most coal (62 percent) was used by utilities to generate electricity. If fuels used to generate electricity are allocated to the ultimate use sector, Appendix Table A-7 results. About 5 percent of the electric power is hydroelectric and about 3 percent is imported.

Appendix Table A-6 ENERGY CONSUMPTION PATTERN

(% of State Total)

Use sector	Natural gas	Petroleum products	Coal	Total
Industry	12	5	2	19
Residential	12	0.5	4.5	17
Commerce[a]	8	5	0	13
Utilities	9	0.5	10.5	20
Transportation	00	31	0	31
Total	41	42	17	100

[a] Commerce includes agriculture, government, turism, construction.

[b] Total state use in 1972 was $7(10)^{15}$ BTU's; total Denver Metro use was about $4(10)^{15}$ BTU's.

Appendix Table A-7 ENERGY CONSUMPTION PATTERN WITH REALLOCATION OF SOURCES USED FOR ELECTRICITY GENERATION[a]

Use Sector	Natural Gas	Petroleum Products	Coal	Total
Industry	3%	4.5%	5.5%	23%
Residential	16.5	1.5	8	26
Commerce	11.5	5	3.5	20
Transportation	0	31	0	31
Total	41%	42%	17%	100%

[a]Footnotes of Appendix Table A-6 apply.

The data in Appendix Table A-8 indicate that if the transportation sector is excluded, natural gas supplies 60 percent of the energy needs of the Denver Metro area. As natural gas supplies are decreasing, partiularly gas imported from Canada, the Denver Metro area is expected to face shortfalls in supply by the 1978-1979 heating season. Small amounts of petroleum products are used to generate electricity, thus shortages of this fuel source would primarily impact the transportation sector, which uses nearly 75 percent of this energy source. Nuclear power is limited to the 330 megawatts scheduled to come on line from the Fort St. Vrain plant in 1977. This represents about 7 percent of the total electric power generated in Colorado in 1975. Coal rather than nuclear power seems to be the favored option as a source of electric power generation to supplant forecasted shortages of natural gas. This option, however, may overtax current and projected supplies of water in Colorado.

The Denver Metro area is highly dependant on supplies of natural gas and petroleum products. The industrial, residential, and commercial sectors of the economy have 60 percent of their energy needs supplied by natural gas. Nearly 75 percent of the petroleum products consumed went to the transportation sector. Projected shortfalls in supplies of natural gas pose a constraint on growth after 1980. In the longer term, increased reliance on coal-based electrical generation will force increased competition for available supplies of water, a limited resource in the Denver Metro area.

OUTDOOR RECREATION SITES

Colorado is divided into several comprehensive planning regions administered by the State. Within these regions are a number of officially designated recreation areas including reservoirs, rivers and streams, natural lakes, cold springs, forests and parks (Reference 11). Map G shows the locations of these recreation areas.

Several types of recreation areas are found near existing and proposed facility sites. The South Platte Greenway program administered by the Platte River Development Committee is located downstream and approximately one mile east of the Denver Metropolitan Wastewater Treatment Plant. The program calls for this 736 acre, 10 mile segment of the river to be improved for recreation uses by 1978. Uses proposed for this segment include boating, bicycling and picnicing. In addition, a trail system along the area's major streams has been proposed to link with the South Platte Greenway. Barr Lake and Barr Lake Duck Club are also located downstream within a few miles of the Denver Metro Plant.

Park and open space acquisition is an ongoing process in the Denver area. Some counties such as Adams have acquired lands to be used to meet future recreation facility demands projected for the next 15 years or more (Reference 16). As the population grows, these lands will be developed. Numerous parks and open space have been proposed or planned by agencies in the Denver area. They include: a park along Slaughterhouse Gulch, Litttleton; the 2,000 acre Grant Ranch, Denver; a 23 acre joint venture between Lakewood and Wheat Ridge along Lakewood's northern city limit; a park in Arvado around a 34 acre lake now being used as a resting place for migratory fowl; and 180 acres of park land recently donated to Aurora by the Buckley Air National Guard Base.

A major problem being experienced by the areas park agencies is vandalism and misuse of park and open space areas (Reference 971). This problem may become more difficult to deal with in the future as service areas become larger and uses become more intense.

Appendix Table A-8 MAJOR HISTORICAL SITES WITHIN THE DENVER AREA

Site name, map symbol[a] and description

CHAUTAUQUA PARK (9) Historic

Camp meetings that included religion, entertainment, and education were initiated in Chautauqua, N.Y., in 1874. When a Texas group came to Colorado to find a site in 1898, Boulder citizens provided an 80-acre meeting ground, a dining hall, an auditorium, and water facilities financed by city bonds, all of which they rented to the Chautauqua association

RIVERSIDE CEMETERY (10) Historic

Denver's oldest cemetery contains the graves of many of Colorado's early pioneers, including Augusta Tabor and Territorial Governor John Evans.

RALSTON DIGGINGS (11) Historic

Gold was discovered near here in about 1849 by a group of Cherokee Indians headed for the California gold fields. Other prospecting parties followed; their discoveries spurred the Pikes Peak Gold Rush of 1859 and opened the frontier of Kansas Territory.

PIONEER SOD HOUSE (12) Historic

4610 Robb Street, Wheatridge
Built by pioneer settlers around 1880, this three-room sod house, with its 30-inch (76-cm) thick walls, is the only remaining structure of its type known to exist in the Denver area.

ARAPAHOE CITY SITE (13) Historic

South side of West 44th Avenue
Arapahoe City was a pioneer mining camp, the earliest town in Jefferson County, organized Nov. 29, 1858. From here George A. Jackson and John H. Gregory set out to make their historic gold discoveries at Central City.

COLORADO RAILROAD MUSEUM (14) Historic

17155 West 44th Avenue
This museum contains many types of railroad engines and cars and an extensive collection of literature on the railroads of Colorado and the West.

BURGESS HOUSE (16) Historic

1015 Ford Street, Golden
This brick structure was built in 1865 by a man named Burgess as a hotel catering to stagecoach passengers and later to train passengers.

STEWART GROCERY (17) Historic

NW corner Water Street and Washington Avenue, Golden
Now (1974) the Landmark Laundromat, this building was once a grocery store, built in 1892 by E. E. Stewart.

TERRITORIAL CAPITOL (LOVELAND BUILDING) (18) Historic

NW corner 12th Street and Washington Avenue, Golden
Built in 1861, this building housed the legislature when Colorado was still a territory. From 1862 to 1867 Golden was the territorial capital of Colorado. Golden was named for Thomas L. Golden who camped on the site in 1858.

ASTOR HOUSE (19) Historic

NE corner 12th and Arapahoe Streets, Golden
Built in 1867 by Seth "The Deacon" Lake, the Astor House boast-of being the most elegant hotel in Colorado, catering to traffic to and from the gold fields.

GEORGE WEST HOUSE (20) Historic

1018 12th Street, Golden
George West built this house in 1871. West was with the original party of the Boston Town Company that was active in founding the city of Golden in 1859.

GOLDEN ARMORY (21) Historic

SE corner 13th and Arapahoe Streets, Golden
Reportedly the largest cobblestone building in the United States, it was constructed in 1913 using 3,000 wagonloads of cobbles.

Appendix Table A-8 . (Continued) MAJOR HISTORICAL SITES WITHIN THE DENVER AREA

Site name, map symbol[a] and description

CALVARY EPISCOPAL CHURCH (22) Historic

SW corner 13th and Arapahoe Streets, Golden
Built in 1867, this church is the oldest Episcopal church in continuous use in Colorado.

COLORADO SCHOOL OF MINES (23) Historic

This respected school of mineral engineering was initially conceived by Episcopal Bishop George M. Randall, in 1866, as part of Jarvis Hall, an Episcopal school.

CLEAR CREEK CANYON (24) Historic, Natural

The Colorado Central Railroad, built in the 1870's, followed the canyon and its north and south forks to the mines of Central City and Georgetown.

BUFFALO BILL'S GRAVE AND MUSEUM (25) Historic, Scenic

William F. Cody (1846-1917), dispatch rider, buffalo hunter, scout, and western showman, was buried here after his death in Denver.

MOTHER CABRINI SHRINE AND ORPHANAGE (27) Historic, Scenic

The Mother Cabrini shrine and the summer home for orphans, on a high ridge in the foothills of the Rockies, have a commanding view of Denver and the Great Plains.

MOUNT VERNON (STEELE) HOUSE (30) Historic

This house was named for Robert W. Steele, a resident of Mount Vernon, who was elected governor of the Territory of Jefferson, a provisional government, in October 1859. He led efforts to establish a regional government and was finally rewarded when Congress established the Territory of Colorado on February 28, 1861.

ROONEY RANCH (31) Historic

Rooney Road and Alameda Parkway
The two-story ranchhouse, begun in 1860 by Alexander Rooney, may be the oldest building still in use as a residence in Jefferson County. The Rooneys once bred Morgan horses for the British Army and U.S. Cavalry.

TRAMWAY POWERPLANT (FORNEY MUSEUM) (32) Historic

1416 Platte Street, Denver
Electric power was needed to drive the trolley cars of turn-of-the-century Denver. In 1901 the Denver Tramway Company built the powerplant at this site because it was close to the railroad, which delivered coal, and to the South Platte River, which supplied cooling water. The building is now the home of the Forney Transportation Museum.

UNION STATION (33) Historic

17th Street and Wynkoop Street, Denver
In 1879 a company was formed to build Union Station as a terminal to serve all the railroads coming into Denver.

TRAMWAY CABLE BUILDING (34) Historic

1801 Lawrence Street, Denver
In 1889 the Denver City Cable Railway Company built this two-story brick powerhouse to shelter its huge operating machinery. At the time, the building was the largest cable-car powerplant in the world.

CONSTITUTION HALL (35) Historic

1507 Blake Street, Denver
Constitution Hall was built in 1865 to house the First National Bank of Denver, Colorado's oldest continuously operating banking house. A delegation met there from December 20, 1875, to March 15, 1876, to draw up the constitution for the State of Colorado.

DANIELS AND FISHER TOWER (36) Historic, Scenic

1101 16th Street, Denver
The dry-goods firm of Daniels and Fisher was formed in 1872 by two eastern merchants. In 1911 a son of one of the founding partners, built a five-story building and a 21-story tower addition to the original store. The tower was patterned by

Appendix Table A-8 . (Continued) MAJOR HISTORICAL SITES WITHIN THE DENVER AREA

Site name, map symbol[a] and description

architect Frederick J. Sterner after the Campanile of St. Marks Square in Venice, and at that time it was the third-tallest building in the United States.

LARIMER SQUARE (37) Historic

Between 14th and 15th Streets on Larimer Street, Denver
Here pre-1900 buildings of early Denver have been renovated and converted to shops and restaurants.

TIVOLI BREWERY (38) Historic

950 W. Larimer Street, Denver
John Good, a Bavarian brewer, founded Tivoli Brewery in 1859. It was named after the Tivoli Gardens of Copenhagen and contains the Turnhalle Opera House, built in 1882.

EMMANUEL-SHEARITH ISRAEL CHAPEL (39) Historic

1201 10th Street, Denver
This attractive little structure is Denver's oldest church, built in 1876 from volcanic rock (welded tuff) quarried near Castle Rock.

ST. ELIZABETH'S CHURCH (40) Historic

1062 11th Street, Denver
St. Elizabeth's Church was begun in 1896 and was consecrated in 1902. It is designed in the German Gothic style and was built of volcanic rock.

TRINITY UNITED METHODIST CHURCH (41) Historic

East 18th Avenue and Broadway Street, Denver
This stately landmark was built during the years 1887-88 under the direction of the Rev. Henry A. Buchtel, later Chancellor of the University of Denver.

BROWN PALACE HOTEL (42) Historic

17th Street and Tremont Place, Denver
The hotel opened on August 11, 1892. Through the years the Brown Palace has been a popular stopover for mineral barons, politicians, and entertainers. It is listed in the National Register of Historic Places, which is maintained by the National Park Service.

CATHEDRAL OF THE IMMACULATE CONCEPTION (43)

301 East Colfax Avenue, Denver
Designed by Leon Coquard, this structure is a magnificent example of French Gothic architecture. Its 36 stained glass windows, made in Munich, Germany, contain more than 20,000 pieces.

DENVER MINT (44) Historic

West Colfax Avenue and Delaware Street, Denver
The Denver mint was built in the Tuscan Palazzo style of architecture during the years 1904-06. The present mint has produced coins of all denominations as well as presidential medals.

BYERS-EVANS HOUSE (45) Historic

1310 Bannock Street, Denver
This Victorian structure was built in 1880 by William N. Byers, publisher of the Rocky Mountain News. Byers sold it to William Gray Evans, sone of ex-territorial-governor John Evans, in 1890. The Evans family was active in railroad building, education, and politics, and was a prominent pioneering force in early Colorado.

MOLLY BROWN HOUSE (HOUSE OF LIONS) (46) Historic

1340 Pennsylvania Street, Denver
This stone house built sometime between 1887 and 1894, was purchased in 1894 by James J. Brown, Leadville mining magnate, and his aggressive young wife, the "Unsinkable Molly Brown." At this residence Mrs. Brown, seeking acceptance in Denver's highest social circles, entertained world-famous theatre and art celebrities.

BUCKHORN EXCHANGE RESTAURANT (47) Historic

1000 Osage Street, Denver
This old Denver restaurant and saloon was opened on November

Site name, map symbol[a] and description	Site name, map symbol[a] and description

24, 1892, by Henry Zietz, Sr. In the early days the Buckhorn was a roadhouse on the trail south out of Denver. Buffalo Bill often stopped to drink and joke with the owner. Theodore Roosevelt also visited the bar. The bar still holds Colorado State Liquor License Number one.

HAL SAYRE'S ALHAMBRA (48) Historic

801 Logan Street, Denver
Hal Sayre was one of the first trained engineers to work in Colorado's mining fields. While other men prospected for gold, Sayre became rich by surveying. As the only surveyor in the mining area, he laid out many mining claims in exchange for a nominal interest in their profits. He was the first to survey Denver City.

GOVERNOR'S MANSION (49) Historic

400 East 8th Avenue, Denver
This colonial-style brick mansion was conceived by Walter S. Cheesman, pioneer Denver druggist, railroad builder, and founder of the city's waterworks. Since 1960 the 27-room mansion has been the official residence of the Governor of Colorado.

GRANT-HUMPHREYS HOUSE (50) Historic

770 Pennsylvania Street, Denver
Two of Colorado's prominent mining families have occupied this 30-room mansion, which was built in 1902 by James B. Grant, second Governor of Colorado. After Grant's death in 1911, the house was bought by Albert E. Humphreys who invested in the mines at Creede and Cripple Creek, and spurred oil development in the Rocky Mountain West.

CODY HOUSE (51) Historic

2932 Lafayette Street, Denver
This house, was owned by Buffalo Bill Cody's sister, Mrs. Mary Decker. Cody died here on January 10, 1917.

PEARCE-MC ALLISTER COTTAGE (52) Historic

This Pennsylvania-colonial-style house was designed by Frederick Sterner and built in 1899 for Harold V. Pearce, manager of the Argo Smelter.

RICHTHOFEN CASTLE (53) Historic

7020 East 12th Avenue, Denver
In the 1880's Baron Walter von Richthofen, Prussian nobleman and soldier, and uncle of Baron Manfred von Richthofen, the famed "Red Baron" of World War I, built the "castle" on the prairie east of Denver from volcanic rock quarried near Castle Rock.

FOUR-MILE HOUSE (54) Historic

715 South Forest Street, Denver
The Four-Mile House, built in 1858, was the last stage station on the Smoky Hill Trail outside Denver.

EUGENE FIELD HOUSE (55) Historic

South Franklin Street and Exposition Drive, Washington Park, Denver
Eugene Field was managing editor of the Denver Tribune from 1881 to 1883. Field is probably best known for the poem "Little Boy Blue." He also wrote "The Dutch Lullaby".

EVANS CHAPEL (GRACE METHODIST CHURCH) (56) Historic

University Park campus of the University of Denver
Evans Chapel, the oldest Protestant church building still in use in Denver, was completed in 1878. It was begun in 1873 by John Evans, Colorado's second territorial governor. It orginally stood across from the Byers-Evans house near West 13th Avenue and Bannock Street. To save the chapel from demolition in 1958, the grandson of Governor Evans, John Evans, raised funds to move it stone-by-stone to the University Park campus where it now stands.

ILIFF MANSION (57) Historic

2160 South Cook Street, Denver
Built as the "Fitzroy Place" in 1892 by the widow of cattle king John Wesley Iliff, the house has become known as the Iliff Mansion.

Appendix Table A-8. (Continued) MAJOR HISTORICAL SITES WITHIN THE DENVER AREA

Site name, map symbol[a] and description

RUSSELL PLACER CAMP (58) Historic

Confluence of Little Dry Creek and South Platte River
William Green Russell, a miner from Georgia, learned from Cherokee Indians about gold in the Pikes Peak region. In 1858 he organized a prospecting party of 60 white men and Cherokee Indians, and on June 24, 1858, they discovered gold in paying quantities at the confluence of Little Dry Creek and the South Platte River, in what is now Englewood. The discovery precipitated the Pikes Peak Gold Rush of 1859.

RED ROCKS PARK (60) Historic, Scenic, Natural

John Brisben Walker originated the idea of a mountain parks system for Denver. In 1937, the outdoor theatre was built in the natural Red Rocks amphitheater and is today a popular concert setting for Denver area audiences.

MORRISON SCHOOL (62) Historic

226 Spring Street, Morrison
Built in 1875 from locally quarried sandstone, this building served as a school until 1955.

FALCON CASTLE RUINS (63) Historic, Scenic

John Brisben Walker, Denver area landholder and founder of Cosmopolitan magazine, dreamed in 1911 of making Falcon Castle the site of the summer White House for the President of the United States. His dream was never realized, however, and the castle was never finished.

COLOROW'S CAVE (65) Historic

This cave served as an occasional campsite for the mountain Indians, the Utes.

WOLHURST (67) Historic

8025 South Santa Fe Drive, Littleton
Wolhurst was built by Colorado Senator Edward O. Wolcott in 1891, it was the scene of extravagant entertaining and historic political meetings.

TWENTY-MILE HOUSE MARKER (70) Historic

West side of Colorado Highway 83, Parker
The house is at the junction of the Smoky Hill and Santa Fe stage route on the Smoky Hill Trail 20 miles (32 km) from Denver.

CARSON CAMP MARKER (71) Historic

East of Wildcat Point on south side of road
This tablet marks the spot where Kit Carson, accompanied by his friend Major D. C. Oakes, built his last campfire, May, 1868.

FRANKTOWN MARKER (72) Historic

West side of Colorado Highway 83, about 1/4 mile (0.4 km) south of intersection with Colorado Highway 86.
This marker commemorates James Frank Gardner, who settled here in 1859 and built a way station, which became Franktown, on the stage line between Denver and Santa Fe.

EAST AND WEST PLUM CREEKS (74) Historic, Scenic

On June 16, 1965, the Plum Creek watershed was the storm center for the most disastrous flood in the history of the Denver area, 14 inches (36 cm) of rain fell in just a few hours. Creeks quickly became ravaging torrants that destroyed trees, highways, bridges, fields, and homes. When the flood reached Denver, it picked up all kinds of rubble that formed dams against bridges and spread the inundation. Damage exceeded half a billion dollars.

PLATTE CANYON (76) Historic, Scenic

Kassler to South Platte
In 1874 the Denver, South Park, and Pacific began work on a narrow-gage railroad through the canyon to connect Denver with the mining camps of South Park and Leadville. Today, a service road along the old railroad bed, provides access for fishermen and bicyclists.

Appendix Table A-8. (Continued) MAJOR HISTORICAL SITES WITHIN THE DENVER AREA

Site name, map symbol[a] and description

WESTALL MONUMENT (77) Historic

West of Dome Rock on the North Fork of the South Platte River
This monument commemorates the death of engineer William Westall, who was killed in an accident on August 28, 1898.

GREEN MERCANTILE STORE (78) Historic

Buffalo Creek
This solid two-story native-granite building has been operated as a store by the Green family ever since it was built in 1898 in the timber camp and tourist stop of Buffalo Creek.

NORTH FORK OF THE SOUTH PLATTE RIVER (80) Historic, Natural

The river route was popular in the days of the Denver, South Park, and Pacific Railroad, and the old hotel at South Platte did a hearty tourist business.

NINE MILE HOUSE (A)

TOLLGATE CREEK STATION SITE (B)

COAL CREEK STATION (C)

SMOKY HILL TRAIL (D,E, AND F)

Three alternate routes of this trail were used in the 1859 Gold Rush. Water availability, Indian problems, and advancement of the railroad from Kansas determined the extent to which each route was used. Drivers followed ridge tops during wet weather and valley bottoms during dry, so the trails wandered over an area several miles (several kilometres) wide. Today, the grass-grown depressions are still visible in some heavily traveled sections.

SMOKY HILL NORTH TRAIL (D)

The last stage to Denver over the Smoky Hill South Trail ran in June 1866. Stock and equipment were transferred to new positions along the Smoky Hill North Trail. Westbound stages to Denver stopped running after the railroad line was completed in 1870.

MIDDLE SMOKY HILL (STARVATION) TRAIL (E)

This trail, first used in 1859, is the oldest of the Smoky Hill routes into Denver.

SMOKY HILL SOUTH TRAIL (F)

In 1865 a new route to Denver supplanted the Middle Smoky Hill (Starvation) Trail.

CHEROKEE TRAIL (G) Historic

About 1849 a band of Cherokee Indians, found placer gold near the junction of Ralston Creek and Clear Creek. Reports of their discoveries contributed to the Pikes Peak Gold Rush of 1859. Later, the same route was used by the frontier stage companies and named the Cherokee Trail.

GOODNIGHT-LOVING CATTLE TRAIL (H) Historic

Along Cherry Creek to Denver
After the Civil War, when the Colorado gold boom was in progress and the miners created a great demand for beef, two Texans, Charles Goodnight and Oliver Loving, attempted to capture the Colorado market. In 1865 they herded 2,000 head of cattle through New Mexico to Denver.

LONG EXPEDITION (I) Historic

Major Stephen H. Long was sent by President James Monroe to explore the southwestern boundary of the Louisiana Purchase. Long was disgusted with the plains of Colorado, called them "the Great American Desert," and felt that nothing could ever grow there. Members of his group, made the first recorded ascent of Pikes Peak, a mountain that Lt. Zebulon Pike had considered not climbable.

DENVER, SOUTH PARK, AND PACIFIC RAILROAD ROUTE (J) Scenic, Historic

Denver to South Park and Leadville via Platte Canyon
This narrow-gage railroad was started in 1874 and took 8 years to complete. It was built to handle the ores from the mines in South Park and Leadville; it soon became a major freight and passenger route and a great tourist attraction.

Appendix Table A-8. (Continued) MAJOR HISTORICAL SITES WITHIN THE DENVER AREA

Site name, map symbol[a] and description	Site name, map symbol[a] and description
GOLDEN GATE TOLL ROAD (K) This road served as a busy shortcut to the Gregory Diggings at Central City. It was built in 1860, and it operated until about 1871, when its business was taken over by the Colorado Central Railroad, which ran a line from Golden to Central City via Clear Creek Canyon.	LEAVENWORTH AND PIKES PEAK EXPRESS, (L) Historic BEN HOLLADAY'S OVERLAND EXPRESS ROUTE Followed the South Platte River valley into Denver In 1859 freighting partners Russel, Majors, and Waddell chartered the Leavenworth and Pikes Peak Express Co. to provide daily service from Kansas to Denver along the Smoky Hill and Platte River Trails. When their business failed, Ben Holladay bought the line in 1862, put the stages on schedule, and quickly dominated Western transportation of that era. He managed a vast transportation empire that controlled over 5,000 miles (8,000 km) of stage lines. In 1866, he sold out to Wells-Fargo, which ran the stages to Denver until the railroad came in 1870.

[a]For location see Map G

Appendix Table A-9. SCENIC SITES WITHIN THE DENVER AREA

Site name, map symbol[a] and description	Site name, map symbol[a] and description

THE FLATIRONS (2) Scenic, Natural

The upraised Fountain Formation dips steeply to the east, providing an impressive backdrop for the City of Boulder.

DEVILS THUMB (3) Scenic, Natural

This resistant sandstone outcrop of the Fountain Formation provides a popular exercise for technical climbus.

BARR LAKE (5) Scenic, Natural

The Rockies provide a panoramic backdrop west of the lake.

RALSTON BUTTES (8) Scenic, Natural

Some residents viewing the buttes from Golden refer to them as "Old Indian Head" because of their fancied resemblance to a reclining human head.

NORTH TABLE MOUNTAIN (15) Scenic, Natural
SOUTH TABLE MOUNTAIN (15) Scenic, Natural

These flat-topped mountains are conspicuous landmarks west of Denver.

BUFFALO BILL'S GRAVE AND MUSEUM (25) Scenic, Historic

The site and museum on Lookout Mountain are owned and maintained by Denver National Parks.

GENESEE PARK BRIDGE (26) Scenic

This graceful bridge provides a picture frame of the Continental Divide for westbound motorists on Interstate 70.

MOTHER CABRINI SHRINE AND ORPHANAGE (27) Scenic, Historic

The Mother Cabrini Shrine and summer home for orphans, on a high ridge in the foothills of the Rockies, have a commending view of Denver and the great Plains.

DANIELS AND FISHER TOWER (36) See Denver Area. Scenic, Historic

The structure was for many years the dominant landmark in Denver.

RED ROCKS PARK (60) Scenic, Natural, Historic

World-famous Red Rocks Park is eroded from eastward dipping beds of the Fountain Formation.

KISSING ROCKS (61) Scenic

South side of Colorado Highway 74 in Bear Creek Canyon. Erosion has sculptured this outcrop of Precambrian rock into a fanciful shape that looks like two people about to kiss.

FALCON CASTLE RUINS (63) Scenic, Historic

The Jefferson County Open Space Program plans to provide access trails and protection for the ruins.

BERGEN DITCH WATERFALL (64) Scenic

West of the Hogback of Dakota Sandstone, Bergen Ditch tumbles off an outcrop of Lyons Sandstone and creates a picturesque waterfall.

DUTCH CREEK VISTA (66) Scenic

Dutch Creek winds through undeveloped rolling plains and has the foothills and Hogback as a scenic backdrop.

DEER CREEK CANYON (68) Scenic

Deer Creek Canyon is a picturesque gorge from its mouth west to Phillipsburg.

DANIELS PARK AREA (69) Scenic, Natural

Much of this rocky gulch area is a Denver Mountain Park.

EAST AND WEST PLUM CREEKS (74) Scenic, Historic

East and West Plum Creeks flow on opposite sides of a low dissected ridge of Dawson Arkose and local buttes capped by ash flow tuff.

ROXBOROUGH PARK (75) Scenic

The colorful Fountain Formation forms spectacular red rock outcrops along the eastern side of the Front Range.

Appendix Table A-9(continued). SCENIC SITES WITHIN THE DENVER AREA

Site name, map symbol[a] and description	Site name, map symbol[a] and description
PLATTE CANYON (76) Scenic, Historic The South Platte River cuts a deep narrow canyon through Precambrian granitic gneiss between the towns of South Platte and Kassler. PINE GULCH (79) Scenic A picturesque stream flows through this little developed gulch, heavily wooded with pine, spruce, and aspen. MARSHALL MESA (4) Natural Sometimes called Pine Ridge, this sandstone shelf on the Laramie and Fox Hills Formations is the site of an unusual plant community east of the mountains. Local hydrologic and microclimatic conditions support a stand of ponderosa pine, juniper, and Douglas-fir. Because of the attractive geologic setting and unsual plant association, researchers from the University of Colorado have looked upon the area as a versatile outdoor laboratory (Biggins and Dodson, 1970).	BARR LAKE (5) Natural, Scenic Originally known as Oasis Reservoir, Barr Lake's marshy shore and good food supply attract many species of water fowl. DANIELS PARK AREA (69) Natural, Scenic Much of the area is a Denver Mountain Park. Pine, juniper, and scrub oak in the rocky gulches provide shelter for small animals and birdlife.

[a]For location see Map G

LAND WASTE TREATMENT SITES

Currently, there is little land treatment of wastewater in the Denver Area. Future plans call for some successive use and reuse of wastewater by urban and agricultural irrigation and domestic or industrial reuse. However, only the city of Westminster has firm plans for land application at this time. A contract with the Farmer's High Line Canal and Reservoir Company has been executed to exchange secondarily treated effluent for raw water in the canal which is presently utilized for irrigation on a one for one basis. (Reference 972) The effluent will be used for crop irrigation, and the diverted raw canal water will be used for the cities municipal use. This action will increase the city's water supply for municipal use and provide further wastewater treatment through land application.

Land application of the treated solid component of sewage called sludge is being made by many wastewater treatment plants in the area. Generally, sludge is sold or applied to city-owned parks and other green areas in the area as a soil conditioner. Some sludge is disposed in landfills. The largest volume of sludge in the area is produced by the Northside/MDSDD #1 treatment complex. Present practice is to dewater undigested sludge thus reducing its volume and truck it to the Lowry Bombing Range where it is mixed with soil. Because of high loading rate of about 30 tons of sludge per acre per year, this practice will be discontinued as soon as an alternative plan can be implemented. Sludge disposal plans for the Denver area are now in the environmental review phase of planning.

A partial alleviation to the sludge disposal problem is the anerobic digestors presently under construction at the Denver Metro Plant. These digestors are expected to reduce the volume of sludge currently being produced by up to 50 percent. The digestors are planned to be in operation by March of 1977. The sludge disposal plans undergoing environmental review call for transport of liquid digested sludge via pipeline to a drying/distribution center in Western Adams County (see Figure II-C). The sludge would be dried on about 600 acres of drying beds, stored for about a year, and sold as a fertilizer/soil conditioner to homeowners, municipalities and farms in the area. The entire site which was selected because of its remoteness from present or projected urban areas would cover 2,000 acres. However, plans for an airport in the vicinity may pose future land use conflicts of some minor degree between the sludge disposal site and urban development attracted by the airport facility. No decision has yet been made on this plan.

TRAFFIC

The predominant mode of intra-city travel in the region is the automobile, which accounts for 97 percent of all trips made in 1974 (Reference 403). The region is also served by bus transit service, which had approximately 470 coaches by the end of 1975. Petroleum-powered transportation modes are served by a fairly extensive network of roads, ranging from local, surface streets to major limited-access highways. Two interstate highways, I-70 running west-east and I-25 running north-south, intersect in Denver, providing both inter-city and intra-city thoroughfares. Five major intra-city corridors extend from the central business district (CBD) to the major cardinal directions and along Cherry Creek. These corridors are, Colfax Avenue, Colorado Boulevard, Federal Boulevard, and Broadway (Reference 403). Growth and development within the region have generally occurred along these corridors, which are .8-to 1.6-km [1/2-mile to 1 mile] wide along their respective thoroughfares. Commercial development surrounds the thoroughfare, and residential areas extend towards adjacent corridors. This sprawl form of growth is typical of large U.S. cities served by a few major transportation corridors leading into the central city.

The existing highway system becomes overloaded at peak traffic times in several areas. A 1970 study by the Colorado Division of Highways found that at 28 percent of the monitored locations traffic volumes exceeded available capacities (Reference 403). Since 1970, total daily vehicle miles of travel have increased 25 percent indicating a worsening of the monitored situation. Appendix Table A-10 illustrates that, as the population increases and people live at greater distances from the CBD and other nodes of activity, absolute and per capita vehicle miles are likely to increase. Such an increase in per capita vehicle miles is greater than the rate of population increase because of the greater distances traveled.

Appendix Table A-10 PROJECTION OF POPULATION GROWTH, VEHICLE MILES TRAVELED, AND MILES/CAPITA/DAY FOR THE DENVER REGION[a]

	1970	1990	2000
Miles/Capita/Day	12.3	15.9	18.0
Population, millions	1.0	1.6	1.8
Daily vehicle miles, millions	12.3	25.4	32.4

[a](Reference 412)

Major highways which have been identified as presently experiencing traffic overload conditions are:

Colfax Avenue from CBD to Englewood

I-25 (Valley Highway) from the Denver-Boulder Turnpike Interchange south past U.S. Highway 6.

I-70/I-25 Interchange, nicknamed the "mousetrap".

Federal Boulevard, Speer Boulevard, Alameda Avenue and Santa Fe Drive, as they approach the CBD (Reference 408).

The following arterials also are congested as they approach the major highways in and out of the CBD:

Wadsworth Boulevard

Hampden Freeway

Sheridan Boulevard

Colorado Boulevard

Relief in the form of further highway construction is being planned. Plans for southwest Denver call for the phased construction of a circumferential highway, I-470, along with the widening and extension of principal arterials, construction of specially designed interchanges, and construction of an arterial bypass along the southwest edge of the region (Reference 401).

Various types of mass transit remedies for present and future congestion problems are being studied by the Regional Transportation District (RTD). RTD has the ultimate goal of developing, maintaining and operating a public transportation system for the benefit of the District's inhabitants (Reference 412).

Appendix Table A-11

INFORMATION ON LOCAL PLANNING IN THE DENVER REGION

Jurisdiction and Address	Agency Head and Telephone	Contact	DRCOG Projected Annual Growth Rate 1975-2000	DRCOG Projected Population Year 2000 (1000's)	Local Projected Population Year 2000 (1000's)	Status of Local Planning
Adams County 450 S. 4th Av. Brighton, CO 80601	Robert Fleming Plng. Director 303/659-2120	Same, interview 1/13/77	Unincorporated Urban: 1.15 Unincorporated Nonurban: 1.38	 83.1 14.8	 Same Same	Comprehensive plan adopted 1975
Arapahoe County 2069 W. Littleton Blv. Littleton, CO 80120	Donald W. Paul Plng. Director 303/795-4450	Same, interview 11/16/76	Unincorporated Urban: 3.22 Unincorporated Nonurban: 2.18	 92.1 1.2	 109.8 Same	Master land use map for urban area adopted 1972
City of Arvada 8101 Ralston Rd. Arvada, CO 80002	Don L. Kinney Plng. Director 303/421-2550	Same, interview 1/4/77	1.51	117.4	127.0	Adopted 1973 (updated biennially)
City of Aurora 1470 Emporia Street Aurora, CO 80010	John Arney Plng. Director 303/750-5000	Same, interview 12/23/76	2.56	228.7	285.0	Land use plan adopted 1973
City of Boulder 1777 Broadway, Box 791 Boulder, CO 80302	Nolan Rosall Plng. Director 303/441-3270	Same, interview 1/14/77	1.39	130.1	153.0	Comprehensive plan adopted by city and county 1970
Boulder County Box 471 Boulder, CO 80302	Ed Tepe Plng. Director 303/442-2880	Same, letter 12/7/76	Eastern Unincorporated County: 2.51 Small Cities[a]: 4.38	 24.7 28.9	 Same Same	Adopted environmental & agricultural elements of comprehensive plan for unincorporated areas
City of Broomfield 8 Garden Office Center Broomfield, CO 80020	Dennis Wigert Act. Plng. Dir. 303/469-3301	Same, interview 12/28/76	4.07	44.5	65.0	Adopted comprehensive plan and future land use map 1973
City of Cherry Hills Village 2450 E. Quincy Ave. Englewood, CO 80110	James M. Small Plng. Director 303/789-2541	No contact	2.77	10.7	Same	
City of Commerce City 5291 E. 60th St.,Box 159 Commerce City, CO 80022	Dale Gilbert Plng. Director 303/287-3485	Plan review only	0.29	20.0	Same	Draft land use plan published 1976
City/County of Denver 1445 Cleveland Place Room 400 Denver, CO 80202	Alan Canter Plng. Director 303/287-2736	Robert A. Damerau Asst. Dir./Planning letter 11/16/76	0.74	633.9	714.6	Current comprehensive plan (date?); land use section about to be updated
City of Edgewater 5845 W. 25th Ave. Edgewater, CO 80214	Keith Daly Chairman/Plng. Commission 303/238-0573	Plan review only	0.28	5.9	Same	Comprehensive plan published 1967
City of Englewood 3400 S. Elati Street Englewood, CO 80110	Richard S. Wanush Dir./Community Development 303/761-1140	Same, interview 1/6/77	0.99	45.9	Same	Comprehensive plan adopted 1969; revision scheduled for completion in 1977
City of Federal Heights 2380 W. 90th Avenue Denver, CO 80221	Wm. L. Kennedy Chairman/Plng. Commission 303/428-3526	David A. Hawker Adm. Assistant letter 11/19/76	2.14	12.9	Same	Master zoning map, date unknown
City of Glendale 950 So. Birch Street Denver, CO 80222	B. L. Heber Plng. Director 303/759-1513	John Bandel letter 11/10/76	3.48	8.7	Same	All property zoned PUD
City of Golden 911 - 10th Street Golden, CO 80401	Chas. L. Hearn Asst. City Mgr. Planner 303/279-3331	Same, letter 11/10/76	2.36	26.0	Same	1970 comprehensive plan was not adopted. Five major growth policies.

[a]Cities of Erie, Lafayette, Louisville and Superior.

City of Greenwood Village 7695 E. Prentice Avenue DTC Bldg. 42 Englewood, CO 80110	Chas. Menkler Plng. Director 303/773-2525	Ida M. Daniels Asst. Planner interview 11/16/76	4.29	10.0	Same	Greenbelt program master plan completed 1973
Jefferson County 1700 Arapahoe Golden, CO 80419 (Uninc-urban/nonurban)	Michael Davidson Plng. Director 303/279-6511	Same, letter 12/29/76	Unincorporated Urban: 7.78 Unincorporated Nonurban: 18.10	 137.9 12.8	 176.0 12.0	Subarea plans adopted; variously dated
City of Lakewood 1580 Yarrow Street Lakewood, CO 80215	James Spore, Dir. Community Develop. 303/234-8850	Chas. Stromberg, Asst. Dir./Commun. Develop. interview 12/22/76	2.23	213.6	250.0	Comprehensive plan adopted 1975
City of Littleton 2450 W. Main Street Littleton, CO 80120	Jon V. Payne Plng. Director 303/794-4214	Same, interview 11/16/76	1.39	47.3	54.3	No comprehensive plan; master zoning map
City of Longmont 4th Av. & Kimbark St. Longmont, CO 80501	Kenneth Dell Plng. Director 303/776-6050	No contact	2.75	67.4	85.7	
City of Northglenn 10969 Irma Drive Northglenn, CO 80233	Jerry Starling Plng. Director 303/451-8326	Wayne Ethridge Planner/Landscape Arch. interview 11/17/76	0.82	38.6	44.0	Master zoning map adopted 1973
City of Sheridan 440 So. Federal Blvd. Sheridan, CO 80110	Harry Halsacre Plng. Director 303/795-3414	Pete Toedman, Bldg. Commissioner interview 1/10/77	3.20	13.2	Same	Management study completed 1974 with 701 grant
City of Thornton 9471 Dorothy Blvd. Thornton, CO 80229	James Keller Plng. Director 303/289-5801	Kim Wolf Planner III interview 11/15/76	3.52	65.5	90.2	Comprehensive plan adopted 1975
City of Westminster 3031 W. 76th Ave. Westminster, CO 80030	John Franklin Plng. Director 303/429-1546	Donald D. Gilmer, Dir. Community Development interview 11/17/76	2.52	58.9	73.3	Comprehensive plan/land use plan adopted 1973
City of Wheat Ridge 7470 W. 38th Av., Box 610 Wheat Ridge, CO 80033	Dennis Zwagerman Plng. Director 303/422-8028	Same, interview 1/12/77	1.27	47.0	44.0	Comprehensive plan adopted 1976
		TOTAL:	2.10[a]	2,241.7[b]	2,576.7[c]	

[a] Regional rate based on 1975 population of 1,331,990 which excludes areas indicated in note (b).

[b] Differs from DRCOG regional projection due to the following omissions as listed in Ref. 231: Communities of Bow Mar, Box Elder, Brighton, Columbine Valley, East Plains and Mountain View; and the areas of Boulder and Jefferson Counties designated "Mtn" and "A-P Urban".

[c] Local forecasts from Ref. 231 or interviews.

Source: Ref. 231 and communications indicated in table.

ECONOMIC ACTIVITY

Historically, the economic base of Denver and its region has rested on primary industries - mining and agriculture - and on its strategic location as a point of east-west transportation and communications. In recent decades, a shift in employment from goods-producing industries such as manufacturing and agriculture to service industries such as trade and finance, insurance and real estate has been experienced, which has been a national trend. Nevertheless, agriculture and related processing and distribution activities have remained a key element of the local economy, while in the last few years, firms with energy-related operations have assumed an increasing role in the regional economic picture. Denver's position as gateway to recreational resources in the Rocky Mountains is another important contributor to the local economy.

Major Types of Economic Activity

Agriculture

Denver lies at a transition point between the plains and the mountains. Agricultural activity in the mountains is principally livestock grazing; in the plains, major crops include alfalfa, small grains, corn and sugar beets, as well as livestock (Ref. 104). Denver is a major agricultural and livestock market, and regional employment in agriculture is high relative to that of the nation, as is shown in Appendix Table A-12.

In terms of crop values, the most important single crop in the Denver region is winter wheat, which, in 1974, accounted for almost 43% of the value of all crops produced in the four countries surrounding Denver. Crop value data are presented in Appendix Table A-13.

Crop value is only a partial index to the overall importance of agricultural activity, because agricultural production in the

Appendix Table A-12

Denver Region Agricultural Employment Compared to U. S. Agricultural Employment, 1970

	Total Civilian Employment (000's)	Employment in Agriculture Number (000's)	% of Total
Denver SMSA	83.8	5.0	6.0
United States	77,308.8	2,700.0	3.5

Sources: U.S. Census of Population, 1970: State Economic Areas (Table 6) and General Social and Economic Characteristics, U.S. Summary (Table 82). Both agricultural counts include forestry and fisheries and exclude food processing.

Appendix Table A-13

Value of Crop Production by County, 1974 (in 000's)

County	Winter Wheat	Corn (Grain & Silage)	Hay	Sugar Beets	All Other Crops	Total
Adams	13,329.0	3,458.0	2,359.5	1,333.0	3,866.2	24.345.7
Arapahoe	4.070.0	394.3	718.1	-----	601.5	5.783.9
Boulder	706.6	3,357.0	2,219.0	2,390.0	2,694.2	11,366.8
Jefferson	293.4	136.0	829.5	-----	369.0	1,627.9
TOTAL	18,399.0	7,345.3	6,126.1	3,723.0	7,530.9	43,124.3

region creates jobs in a variety of other sectors, in sectors, including manufacturing, transportation, wholesale trade, services, and finance-insurance-real estate. In California, a statewide multiplier for agricultural activity has been estimated between three and four, meaning that for each $1 of agricultural production, the state enjoys $2 to $3 of additional production and services related indicated to agriculture (Monthly Summary of Business Conditions, Security Pacific Bank, September 30, 1976.

The same kinds of interindustry effects of agricultural activity have been observed in Colorado. Researchers at Colorado State University have explored linkages between agriculture and other industries in portions of Admas and Jefferson Counties north of Denver. The research team calculated the dollar impacts on the local economy which would be experienced if agricultural production on the lands lying within the service areas of three irrigation companies ceased.

The researchers found that virtually every sector of the economy would experience decreases in demand, resulting in reductions in employment and income. Only the direct effects were calculated. The estimate of potential impact is conservative because it excludes indirect effects: each industry sector will experience reduced demand from other sectors due to reduction in sales to agriculture. A summary of the direct effects is presented in Appendix Table A-14.

The CSU study illustrates the importance of agriculture to the economy of the Denver region. The contribution of agriculture to the region's economy lies only in part in the proximity of Denver to lands under agricultural production; it also derives from Denver's role as a regional center of manufacturing, finance and trade. This role will permit the Denver region to continue to derive economic benefits from agriculture and to provide goods

Appendix Table A-14

Direct Effects of Agricultural Activity on Other Sectors of the Economy

Sector	Reduction in Total Output ($000)	Direct Reduction in Employment (person-years)	Direct Reduction in Income ($000)
Agriculture	12,516	308	2,441
Mining & Other Extractive Industries	70	2	17
Manufacturing	3,092	68	573
Transportation, Communication & Utilities	685	23	204
Trade	1,324	34	204
Services	2,751	124	619
Education	30	3	16
TOTAL	20,468	562	4,974

Source: Colorado State University, Environmental Resources Center, Physical and Economic Effects on the Local Agricultural E Economy of Water Transfer to Cities, October, 1976.

and services to agricultural interest even while agricultural activity becomes increasingly distant from Denver due to urbanization and other factors.

Within the Denver region, prospects for furture agricultural production depend, to some extent, on the continued availability of agricultural land and supportive resources, particularly water. Of the major Denver region crops discussed above, only winter wheat is grown without irrigation; corn, sugar beets and alfalfa hay require irrigation. Transfer of water from agricultural to urban uses may result in the loss of agricultural production: conversion of land from irrigated to non-irrigated farming use can require several years. The issue of transfer of water rights from agricultural to urban uses is addressed elsewhere in this report.

The land itself is, of course, the other major requirement of agricultural production. As metropolitan areas grow, there is pressure for conversion of vacant land at the fringes of the urbanized area to urban uses. Much of the growth that has taken place in the Denver region since 1950 is on land once used for agriculture. Using Adams County as an example, researchers at Colorado State University have found that about 11,540 acres of land within the boundaries of three irrigation companies were converted to urban uses between 1957 and 1974. Of these, about 8,100 were cropland, 1,390 acres were grassland, and 2,045 were idle. Some of the idle land had previously been used for crops, which parallels national data indicating that agricultural conversion is often a two step process: cropland to idle, and idle to urban.

Data on agricultural land patterns for a two-county area- Adams and Arapahoe - confirms the CSU study, showing that, over time most urban land comes out of the cropland category. Appendix Table A-15 presents historic data on agricultural land use in Adams and Arapahoe counties for 1961 and 1970. About 56% of the gross addition to urban land during the 1960's came from cropland. However, the total acreage in cropland did not decline over this period, because land in other open land categories was converted to cropland. The net addition to cropland was about 5400 acres, of which about equal amounts came out of pasture and range and out of open idle.

These data suggest that, while urban uses are eroding open lands, it is idle land thatis most subject to urban conversion. The fact that idle and lower-intensity agricultural uses were being converted to croplands indicates anticipation of continued strength in the markets for the region's crops. This perception squares with recent observations of trends in the price of agricultural lands,

Appendix Table A-15

Agricultural and Urban Land Use in Adams and Arapahoe Counties, 1961 and 1970

	Land Use		
	1961	1970	Net Change
Cropland	615.2	620.7	+ 5.4
Pasture and range	294.4	308.1	+13.7
Open idle	245.2	192.1	-53.1
Forest	9.3	7.6	- 1.7
Urban	80.3	115.0	+35.7
Other*	63.6	64.4	+ 0.8
TOTAL	1308.0	1307.9	---------

*Other = farmsteads (farm buildings, machinery sheds, feed lots, etc.), bodies of water, drainage and irrigation ditches and government grain storage bins.

Source: USDA: Dynamics of Land Use in Fast Growth Areas, 1976.

which rose 14% nationally between March 1975 and February 1976. This increase appears to arise from perception of the agricultural value of the land, rather than its speculative value for other uses, as 85% of the purchases, 93% of the acres and 92% of the values of transferred land were for agricultural use only (Farm and Land Realtor, September 1976).

Thus, historic data and trends suggest continued strength in the agricultural sector of the region's economy, notwithstanding probable future loss of some agricultural land to urban use. However, these changes in combination with increased competition for available water, and poor market conditions for farm products are sapping this basic strength.

Non-agricultural Activity

The Denver region enjoyed a significant economic expansion in the past three decades, and particularly in the 1960's. Employment

In all major non-agricultural sectors of the region's economy grew at a faster rate than in the nation during the second half of the 1960's and are expected to continue to surpass national growth through the 1970's (Denver Urban Observatory: The Economic Base of Denver: Implications for Denver's Fiscal Future and Administrative Policy, 1974). During the 1940-1970 period, employment in the five-county Denver region increased at an average rate of 3.7% per year, while state and national employment grew at rates of 3.0% and 1.7% respectively. (DRCOG: Cognotations, December, 1976). In 1970, about 60% of Colorado employment was located in these five counties.

In 1975, non-agricultural employment in the Denver Region numbered about 661,400. About 65% of these jobs are concentrated in three sectors: Trade, services and government (including military). Denver's economic mix is more strongly concentrated than the U.S. economy as a whole in the service-producing sectors than in the goods-producing sectors.

This memorandum reviews implemented and planned reuse projects of the water supply agencies in the Denver area. Information on reuse projects was derived from previous studies of the subject by CH_2M-Hill Inc. and the Denver Regional Council of Governments during the PL 92-500 Section 208 water quality management planning process, reports of on-going research by the staff of the Denver Water Department, documentation of the plans of several of the water supply agencies, and contacts with representatives of other water supply agencies.

Previous reports on reuse in the Denver area consider only direct reuse, i.e. potable reuse, industrial reuse, urban irrigation and agricultural reuse by piping effluent to an irrigation ditch in exchange for raw water supplies. This memorandum will also consider more indirect agricultural reuse by placing effluent in the stream system to exchange for raw water supplies. The indirect exchanges are cost efficient and will limit the amount of effluent available for the direct types of reuse.

Colorado water law restricts the use of in-basin or tributary water under a water right to the level of consumptive use established historically through excercise of the right. Expanding the consumptive use under the right results in injury to downstream water rights and particularly to downstream junior water rights. This effect is the basis for decisions by the Colorado Supreme Court which prevent reuse of in-basin water which has been historically diverted and used by the Denver area water supply agencies. The question of the extent to which the restriction applies to in-basin water used historically for agricultural use and transferred to municipal use with a subsequent reduction in the amount of consumptive use is being considered at the present time by the Colorado Supreme Court. The City of Aurora is aurguing that reuse to the extent of the historic consumptive use would not materially injury other water rights.

The Colorado Supreme Court has sanctioned the reuse of water not historically tributary to the basin in which the initial use is made. Non-tributary water includes trans-basin diversions, water derived from bedrock aquifers and developed waters. Trans-basin diversions are the most significant of the non-tributary waters in terms of present use and availability for reuse in the Denver area.

Trans-mountain diversions are being made at this time by the Denver Water Department and the Cities of Aurora, Englewood, and Golden. The diversions are made from the Fraser, Williams Fork, Blue and Eagle Rivers, tributaries to the Colorado River, through an extensive network of diversion structures, reservoirs, ditches and tunnels. From 1974 through 1976 these diversions averaged approximately 114,750 acre-feet per year. The system has the potential to divert up to 200,000 acre-feet per year. Diversions of non-tributary ground water by all water supply agencies in the Denver area amounted to approximately 3,000 acre-feet during 1975. Approximately 50% or less of the return flow from non-tributary ground water was collected for centralized waste water treatment.

Implemented reuse plans by the major Denver area water supply agencies have the potential to amount to approximately 50,900 acre-feet per year. Of this total approximately 900 acre-feet is reused for urban irrigation of recreation facilities. The Denver Water Department has implemented a program having the potential for up to 50,000 acre-feet to be reused by indirect exchange with agricultural water users for additional water supplies.

The following sections describe the implemented and planned reuse projects of the Denver area water supply agencies. These projects are summarized in Table 1.

ARVADA

Raw water supplies for the City of Arvada are obtained from Denver's trans-mountain diversion through the Moffat Tunnel. The City is contractually limited to 19,000 acre-feet per year of trans-mountain water and cannot reuse the return flow from it. In 1975 the City obtained approximately 14,500 acre-feet of trans-mountain water from Denver.

The City has filed for a water right to reuse a portion of the effluent from the city's wastewater treatment plant. The filing is based on return flow from six wells which divert non-tributary ground water to supplement the city's water supply during peak demand periods. During 1975 these wells produced approximately 200 acre-feet of water. The city plans to utilize the return flow by exchange for additional water supplies from Clear Creek.

AURORA

The City of Aurora obtains most of its raw water supplies from the Homestake Project which mades trans-mountain diversions from the Eagle River to the Arkansas River and South Platte River Basins. The city's rights presently have the potential yield approximately 13,000 acre-feet per year. In 1975, the city obtained approximately 10,000 acre-feet from the project. The Homestake Project will be expanded during the mid-1980's to yield the city an average of 30,000 acre-feet per year. The city obtains the remainder of its water from the South Platte River, but maintains a standby well field which could produce 1,600 acre-feet of non-tributary ground water. Estimating a 60% return flow from the trans-mountain diversions, the city could presently reuse 7,800 acre-feet per year and may be able to reuse 18,000 acre-feet per year by the mid-1980's.

The City of Aurora presently reuses effluent from its 1 mgd Sand Creek wastewater treatment plant for urban irrigation of a golf course. This reuse amounts to approximately 550 acre-feet per year. The city is considering plans for expanding reuse of return flows from trans-mountain diversions for additional urban irrigation, industrial use and potable water supply or alternatively lease, sale or exchange to obtain additional water supplies.

A portion of the City of Aurora's raw water supplies are obtained from agricultural water rights which have been transferred to the city's water intake. The city contends its consumptive use is 12 to 37% smaller than the historic consumptive use under the rights. The city has filed suit to reuse the transferred agricultural water to the extent that its use will be equivalent to the historic use under the rights. A decision favorable to Aurora will provide an additional 800 to 2,600 acre-feet of water which could be reused by the city.

BOULDER

The City of Boulder has considered a number of reuse plans in recent years. None have yet proven to be feasible due to economics or present water law. Boulder obtains approximately 11,500 acre-feet of trans-mountain water through the Colorado-Big Thompson Project, but by contract cannot reuse the return flows from this water. The planned Six Cities Project to make trans-mountain diversions may provide Boulder an additional 10,000 acre-feet of water per year. The return flows from this project should provide Boulder approximately 6,000 acre-feet annually for reuse.

DENVER WATER DEPARTMENT

The Denver Water Department is the principal water supply agency in the Denver area. Denver presently can supply up to 300,000 acre-feet of water in a dry year. About 60% of this total would be derived from trans-mountain diversions and the remainder from the South Platte Basin. Denver's use of the trans-mountain diversions has averaged 106,679 acre-feet annually from 1974 through 1976 and return flows from trans-mountain water have averaged 53,284 acre-feet annually.

The Denver Water Department has sponsored research into reuse for many years. Early studies eliminated consideration of extensive industrial reuse or urban irrigation due to the costs of distribution. Denver has initiated planning of a 1.0 mgd pilot treatment plant for potable reuse to be constructed by 1980. If the plant can be operated safely in terms of producing potable water and public acceptance remains high, a 100 mgd plant will be constructed by 1990.

Denver's present reuse project involves both direct and indirect reuse of return flow from trans-mountain diversions for agricultural irrigation under exchange agreements and court decisions with irrigation ditches located below Denver on the South Platte River. Under the terms of a recent decision by the Colorado Supreme Court, the Burlington Ditch Company has paid for the construction and the operation and maintenance since 1972 of a pumping plant to deliver secondary treated effluent from the MDSDD #1 plant to the Burlington Ditch. The pumpage occurs when there is insufficient stream flow at the ditch headgate to fill the decreed amount of diversion under the call in effect. Denver has an agreement to deliver additional effluent to the ditch through the pumping plant at Denver's expense to exchange for raw water supplies diverted at its intake on the South Platte River. From 1974 to 1976 an average of 19,300 acre-feet annually have been delivered to the Burlington Ditch from MDSDD #1 plant.

Denver began late in 1976 to exchange return flow from trans-mountain water with irrigation ditches below Denver. The return flow is discharged to the South Platte River at the MDSDD #1 plant and exchanged for water diverted at Denver's intake. In all, exchange of the return flow from trans-mountain diversions for water diverted at Denver's intake is expected to amount to less than 50,000 acre-feet annually. Exchange of effluent for raw water is less expensive than potable reuse and is preferred by Denver.

A Supreme Court decision rendered during 1976 clouds the extent to which Denver can reuse return flows from its trans-mountain diversions. In litigation between Denver and the irrigation ditches on the South Platte River below Denver the Court upheld in principal Denver's right to reuse the return flows to the extent that they can be identified by Denver. The Court denied, however, an exchange proposed by Denver utilizing trans-mountain return flows on the basis of a 1940 contract agreement between Denver and the downstream ditches. In the contract Denver agreed to apply its return flow from trans-mountain water to offset evaporation from its reservoirs on the South Platte River above the ditches. The decision did not specify the extent to which present return flows are committed by the 1940 contract. Denver maintains that only the 1940 level of return flows are involved. Denver has proceeded since late 1976 to replace the evaporation with storage from the reservoirs in order to negate the terms of the contract and clarify the availability of its return flows for reuse.

ENGLEWOOD

The City of Englewood obtains its raw water supply from the South Platte Basin. The city owns a small trans-mountain diversion which is utilized by exchange for water which is supplied by the Denver Water Department. The rights to reuse this water have been contracted to Denver. The city has not yet implemented a reuse project, but is considering reuse through urban irrigation.

Fitzsimmons Army Medical Center

Effluent flows from Fitzsimmons average 0.45 mgd. All effluent is reused to irrigate a golf course from May through October. This reuse amounts to approximately 233 acre-feet per year. There are no plans for future expansion of facilities at Fitzsimmons.

GOLDEN

The City of Golden obtains an average of 250 acre-feet of water per year through its water rights in the Berthoud

Pass Ditch which makes a trans-mountain diversion from the Fraser River to Clear Creek. Sewage from Golden is presently treated at the Metropolitan Denver Sewage Disposal District No. 1 plant and the return flow is not physically available to the city for reuse. The city is considering withdrawal from the District and construction of a wastewater treatment plant to enable reuse by urban irrigation or by exchange for water supplies from Clear Creek.

LAKEWOOD via SOUTH LAKEWOOD SANITATION DISTRICT

The City of Lakewood obtains most of its water supplies from the Denver Water Department. Denver has retained the right to reuse the return flow from the water it provides. The water is treated and delivered by a number of water companies. The South Lakewood Sanitation District serves a population of 18,500 in Lakewood. Effluent flows from the District total 1.5 mgd. Approximately 0.2 mgd is reused by urban irrigation of a nearby golf course. This reuse amount to approximately 100 acre-feet per year. Denver has requested that this reuse be stopped. On-going 201 facility studies by the District have identified potential reuse of 3,250 acre-feet for urban irrigation. An agreement with the Denver Water Department will be required to enable reuse at present or expanded levels.

LITTLETON

The City of Littleton obtains its entire water supply from the Denver Water Department, and has not implemented a reuse project as Denver has retained the right to reuse the return flow. The city is in the early planing stages for reuse of 500 to 600 acre-feet annually for urban irrigation. An agreement with Denver will be required to implement the planned project.

NORTHGLENN

The City of Northglenn presently obtains its water supplies from the City of Thornton, and has not yet implemented a reuse project. The city is planning to expand its own water supplies through an agreement with the Farmers Reservoir and Irrigation Company (FRICO). The plans call for the city to be able to exchange treated wastewater delivered directly to the FRICO system for up to 7,785 acre-feet of stored water from Standley Lake annually. Northglenn will return the amount divered from the lake plus 10% to be made up of non-tributary ground water, surface water divered under the cities water rights on Clear Creek and treated wastewater. FRICO will specify the quality of the replacement water and is not obligated to deliver water until all physical facilities are constructed. Additional obligations of the city are to demonstrate economic ability to perform the construction, initiate construction prior to a 12 month deadline.

THORNTON-WESTMINSTER

Neither of these cities has implemented a reuse project. The cities are planning to exchange effluent from the future Big Dry Creek Wastewater Treatment Plant with agricultural water users to obtain additional water supplies. The project is currently in the 201 facilities study process. A study undertaken by Westminster shows the secondary effluent will be of equal to better quality than the ditch water at the point where the effluent will enter the ditch system.

Table 1

IMPLEMENTED AND PLANNED REUSE PROJECTS IN THE DENVER AREA

	Existing Projects	Future Plans
City of Arvada	Filed water right for 1.55 cfs of return flow.	Exchange return flow for additional water diversion from Clear Creek.
City of Aurora	Urban irrigation with 1 mgd during irrigation season.	Increase urban irrigation to 3 mgd. Implement industrial and potable reuse. Sale, lease or exchange return flows to develop additional water suppli
City of Boulder	None	The reuse or exchange of return flow generated from Six Cities Project water supply.
Denver Water Department	Exchange of up to 50,000 acre-feet of return flow for additional water supplies. Research into potable reuse.	Construction of a 1 mgd potable reuse plant by 1980 and a 100 mgd potable reuse plant by 199[illegible] Exchange return flow for additi[illegible] water supplies.
City of Englewood	None	Urban irrigation.
Fitzsimons Army Medical Center	Urban irrigation with o.45 mgd during irrigation season.	None
City of Golden	None	Urban irrigation. Potable reu[illegible] of return flow from urban irrigation.

Table 1 - continued

	Existing Projects	Future Plans
South Lakewood Sanitation District	Urban irrigation with 0.2 mgd during irrigation season.	Expanded urban irrigation.
City of Littleton	None.	Urban irrigation.
City of Northglen	None.	Exchange return flow with agricultural water users for additional water supplies and storage.
City of Thornton	None.	See City of Westminster below.
City of Westminister	None.	Exchange return flow from Thornton and Westminister at planned Big Dry Creek wwtp with agricultural water users for additional water supplies and storage.

State of Colorado
EXECUTIVE CHAMBERS
DENVER

RICHARD D. LAMM
GOVERNOR

January 7,1976

Dear Fellow Coloradan:

Government makes a variety of decisions on a daily basis which have great impact on Colorado's growth and development. Questions of energy, transportation, rural development, higher education, and transmountain water diversion, as well as many others, all have long-range implications for Colorado's future. Today, these decisions are made without long-term policy guidelines.

Many other states have developed long-range growth and development plans. Some are legislative, some are executive. It is my strong belief that Colorado needs such a long-range growth and development plan. I would like to facilitate the development of such a plan to guide governmental action and, to some extent, non-governmental action.

No one person or administration can develop such a plan unilaterally. We, however, do have a record in Colorado of past policy statements and proposals made by the legislature, the executive branch, and by various boards and commissions of the previous administrations. We have scrutinized these past studies and proposals and found what we think are consistent themes concerning Colorado's future. We have brought together these earlier statements and studies and made an amalgam of them into one broad policy statement.

It is not meant to be perfect, but rather is designed to serve as a springboard for discussion. It is a proposal which needs input from many Coloradans, and a proposal on which I would like your comments and suggestions. I have already visited several Colorado communities in an effort to seek out the views of a variety of citizens concerning growth and development, and I plan to continue this practice in the future.

Some people will think this statement too general, some too specific; I feel, however, that with the increasing pressures on Colorado, we must have a growth and development plan which has a broad consensus and which can help define the direction of Colorado's future.

Sincerely,

Richard D. Lamm

RICHARD D. LAMM
Governor

GOALS AND OBJECTIVES FOR COLORADO'S LONG-RANGE GROWTH AND DEVELOPMENT

As we approach 100 years of statehood, Colorado is at a most crucial point in its history. Never before have Coloradans been faced with decisions of such magnitude as we face today, and never before have these decisions promised to influence so dramatically the direction of Colorado's future growth and development. Unfortunately, today these determinations must be made without guidance from a generally accepted long-range policy framework.

If Colorado is to remain and improve as a desirable place to live, we must begin now to formulate a State policy on growth and development. Specifically, Colorado will need to consider the desired long-term development of (a) its economy; (b) its population settlement patterns; (c) its natural and manmade environment; (d) its social environment; and (e) its governmental structure. The following statements, which represent a resolution of widely divergent views of what is best for Colorado, are a synthesis of a number of recent policy studies concerning each of these five areas. (See Appendix A)

COLORADO'S ECONOMY

Colorado must continue to encourage a diverse and stable economic base tailored to the rational and healthy long-range growth of the State. In building such a base, we must guarantee that the quality of life in Colorado is not diminished. The beauty of our state can be preserved while still providing jobs for young people just entering the labor market and without jeopardizing the jobs of those already in the work force.

(a) Colorado must attract and provide incentives for a variety of industries which are economically and socially beneficial, environmentally desirable, relatively insulated from adverse external influences and possessing sound objectives for the future. A special effort must be made to increase job security within those industries which are particularly sensitive to downturns in the national economy.

(b) Colorado's agricultural economy must be preserved and its development expanded. We must prevent unnecessary conversion of prime agricultural land and irrigable water to non-reversible uses.

(c) A statewide effort is being made by state and local governments, local Chambers of Commerce and their industrial foundations as well as private businesses to identify and establish regional areas desiring additional growth. Efforts also are being made to revitalize those geographic areas which have been losing population. We commend this effort and believe that a specific attempt must be made to provide people in rural areas with meaningful jobs near their homes.

(d) Colorado state government must continue to encourage national awareness and expanded participation in Colorado's tourist and recreation industry. This must occur while carefully striving to avoid exploitation of our statewide natural resources.

(e) An effort must be made to encourage job generating industries to locate in both out-state areas where growth is desirable and inner-city areas suffering from either high unemployment or high loss of population.

(f) Colorado is encouraging job-related training and placement services in areas of unemployment. An intensified effort is being made to improve job information and aid those who want to move to growth centers where employment is or will become available.

(g) Transportation growth policy, in addition to addressing the basic job of moving people and goods, also should address the objectives of economic development, the use of resources, preservation of private and public investment, and the individual's need for effective mobility.

POPULATION SETTLEMENT PATTERNS

Colorado state government will help local communities prepare for projected growth while striving to redirect excessive Front Range growth patterns.

(a) A specific effort must be made to balance the distribution of population in the state. Drawing from recommendations made in recent legislative and executive studies, the following efforts should be highlighted:

1) Encourage primary new economic growth, especially in areas outside the Front Range, but also in Front Range areas where economic growth is needed to create job opportunities for Coloradans.

2) Seek methods to motivate growth in selected areas of the Eastern Plains and South Central Region which can benefit from such growth. (See map detailing these regions in Appendix B)

3) Assist local governments in managing growth in the Mountain Region in order to accommodate the preservation of natural attractions in these areas.

4) Oversee and support the phased growth of the Northwest Region in accordance with the area's ability to provide necessary public services, while realizing the constraints imposed by available water resources.

(b) Colorado must encourage and help to create settlement patterns that best satisfy people's needs and reduce the cost of providing public services.

(c) Particular efforts must be made to minimize urban sprawl and encourage the revitalization of satellite cities around existing metropolitan areas.

(d) Net in-migration to the State must be moderated.

(e) A special attempt must be made to encourage greater job opportunities for the citizens of Colorado. The introduction of new jobs in these areas which can directly benefit from enhanced employment and increased population levels will be a specific objective.

NATURAL AND MANMADE ENVIRONMENT

All Coloradans must work together to assure the optimum use of the State's natural resources and manmade environment. Our past development has always been heavily influenced and limited by the availability of water, and recent history indicates that the finite nature of our water and energy resources will significantly influence Colorado's development.

Our efforts must be directed toward maximizing the individual human benefit while assuring the proper balance between man and nature. This balance will be increasingly tested should uncoordinated growth be allowed to continue indefinitely.

(a) We need to promote in all of our citizens a sense of stewardship and trusteeship of our natural resources and our environment. Those who lessen the burden should be rewarded while those who increase the burden should be penalized.

(b) A special effort must be made to encourage and expand the arts, as well as to provide additional recreational facilities to meet the needs of all Colorado citizens.

(c) Through both public and private participation, areas damaged by man's activities, such as strip mining, can and must be restored and reclaimed.

(d) A similar effort must be made to restore and upgrade the deteriorating areas of our cities.

(e) A specific effort must be made to protect, preserve, enhance, and manage Colorado's wildlife for the benefit and enjoyment of the people of Colorado, as well as its visitors. Management of game and fishing resources will receive particular attention in the short term.

(f) Through public and private incentives, Colorado state government must lead the effort to maximize the recycling of all reusable resources.

(g) Colorado state government must encourage the expanded utilization by local governments of all available planning tools and, where necessary, provide additional mechanisms to insure the conservation of fragile, scenic, and open space areas. Decisions, once made, must not give way to stubborn opposition or protracted litigation by self-serving interest groups.

(h) Colorado must develop a state water management system which provides an adequate supply of quality water, and which recognizes the social and economic impact of distribution and use.

(i) It is the policy of the state to encourage and assist the housing industry in its efforts to upgrade existing housing, redevelop deteriorated areas, and furnish an adequate supply of new housing.

(j) In order to slow down the proliferation of cars and reduce the damage that automobile pollution does to the environment, an integrated transportation system must be provided both within and between cities of Colorado. This system also should be mutually compatible with Colorado's regional neighbors.

(k) Realizing that the energy resources of Colorado are of national concern, we must seek to aid the needs of the nation without irreversibly degrading the State's environment or water resources. Alternative energy sources -- solar, geothermal, and wind -- merit special developmental efforts.

(l) Colorado state government will discourage and prevent construction of energy conversion plants in the State of Colorado which would result in the blatant exploitation of Colorado's resources by out-of-state interests.

SOCIAL ENVIRONMENT

Uncontrolled and unplanned growth places great strains on the social environment.

All Coloradans desire to preserve our historical and cultural heritage while maintaining and enhancing the principle of individual choice. The State must be ready to respond to problems induced by growth or stagnation in such areas as education, crime, welfare, and physical and mental health. We live in a civilization of shared values, based on a family and community-oriented society. Government efforts should be designed to strengthen the family as a social unit, and encourage a sense of community in all of our people.

(a) Services must be made available to help Colorado citizens adapt to the demands of modern living and assure everyone the minimum necessities of life and equal opportunities for self-fulfillment.

(b) Colorado state government has endeavored to provide an educational system that meets the needs for intellectual development and career preparation, career maintenance, and career change. Colorado must continue to support and emphasize the importance of an educated citizenry and a productive, well-trained work force.

(c) The quality of physical and mental health services can be improved within all parts of our state. Diagnostic communication services with centralized health facilities should receive particular emphasis in the short term.

(d) The quality of protection provided for both property and lives of Colorado citizens must be improved. Colorado's correctional system has received and will continue to receive close scrutiny in the immediate future.

GOVERNMENTAL STRUCTURE

We must make a reality of the phrase "government of the people, by the people, and for the people." Government must become a conciliator, arbitrator and coordinator. We must explore more the ways to get government out of our lives in order to increase the freedom of choice of the individual. Public employment must be recognized as an honorable and worthy business and profession. We must exact of our government employees the highest standards of ethics, honesty, and integrity.

(a) State government should be decentralized and reorganized wherever possible to improve state services and help divert growth outside the immediate Front Range area.

(b) Specific efforts must be made to influence federal, regional, and local governmental agencies to be responsive to the State's long-range development policies.

(c) Public and private investments must be sought and encouraged for water projects, utilities, transportation, and other major projects directly tied to the implementation of Colorado's long-range development plan.

January 7, 1976

APPENDIX A

HISTORICAL SUPPORT INFORMATION

The attached comments are drawn from the following policy statements and proposed legislative items:

1. COLORADO: OPTIONS FOR THE FUTURE (Final report of the Colorado Environmental Commission) March 1972.

2. DESIGNING FOR GROWTH (Report of the Committee on Balanced Population of the Forty-eighth General Assembly) November 1972.

3. Bill proposing a "COLORADO STATE POLICIES ACT" (S.B. 377) 1973.

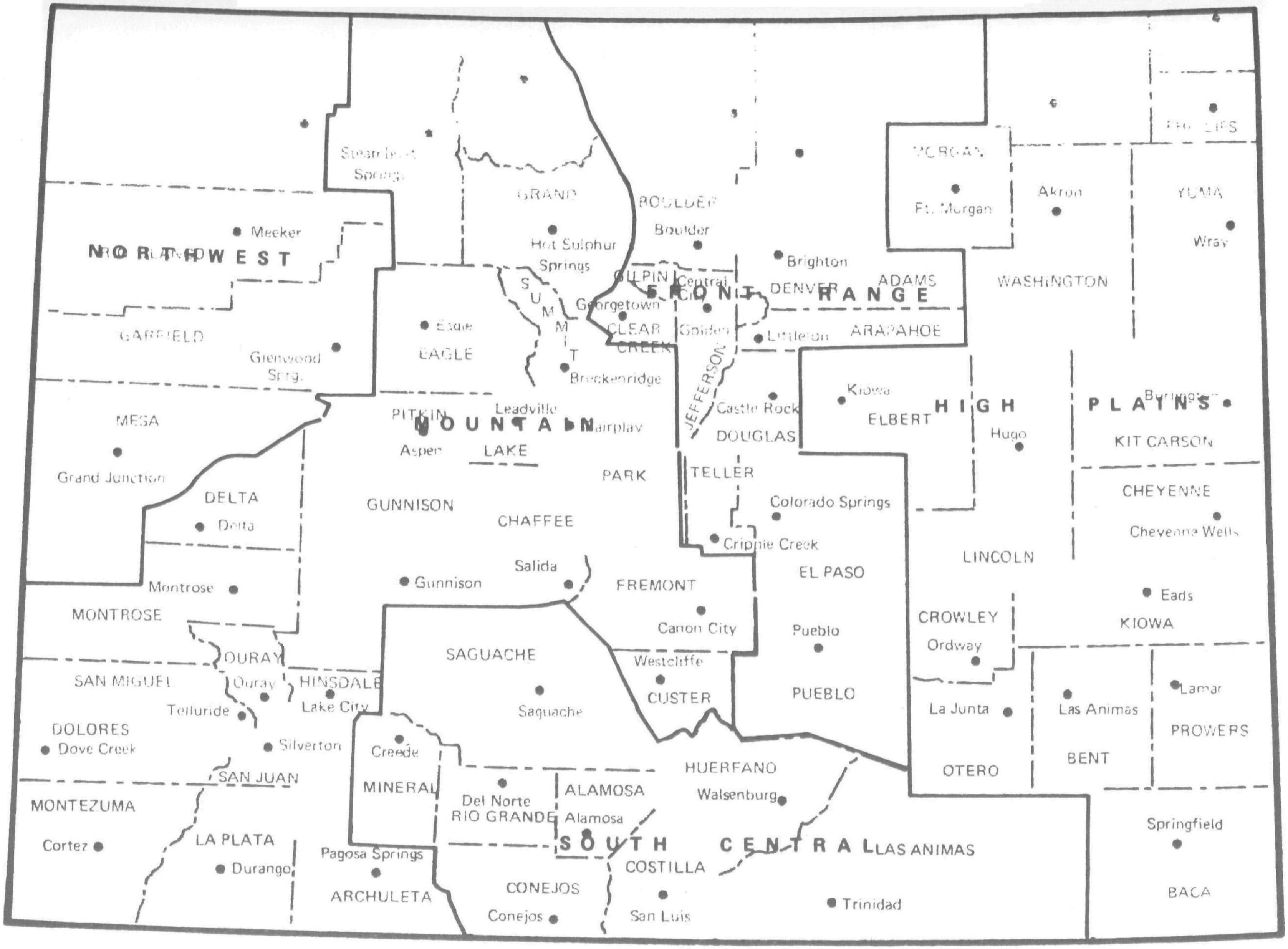
4. A LAND USE PROGRAM FOR COLORADO (Report of the Colorado Land Use Commission) January 1974.

5. THE REPORT OF THE COLORADO RURAL DEVELOPMENT COMMISSION December 1973.

6. Bill proposing "REGIONAL PLANNING AND MANAGEMENT ACT" (S.B. 244) 1973.

7. Amendments to the "COLORADO LAND USE ACT" (H.B. 1041)1974

THESE ARE THE REGIONS MENTIONED ON PAGE 2, SUBPARAGRAPH (a-2)



THE FIVE LAND USE PLANNING REGIONS

APPENDIX B

PLAN POLICIES

AS ADOPTED BY THE
DENVER REGIONAL COUNCIL OF GOVERNMENTS
JANUARY 17, 1973
AMENDED JUNE, 1974

1. A population level below 2,350,000 should be encouraged for the Denver Metropolitan Statistical Area by the year 2000. In all planning activities conducted by the Denver Regional Council of Governments, a year 2000 forecast of 2,350,000 people for the five county Denver Metropolitan Area will be used.

2. The Central Business District of Denver will be encouraged as the major high density core of business, cultural, governmental, commercial and residential activity. Major high density corridors ease, west and south from the CBD shall be encouraged.

3. Several major activity centers shall be encouraged in the Metropolitan Area.

4. New, low density, residential growth should be encouraged only in locations contiguous to existing urban areas while recognizing local ecological, environmental or social concerns as they might affect the location of a specific development.

5. New industrial development should be encouraged only insofar as suitable locations could be found where environmental hazard potential can be effectively controlled or minimized. Major new employment concentrations of any type should be closely analyzed as to their total regional and state impact, which analysis should carefully consider the adverse costs, such as peak hour travel, work trips, and public service costs.

6. Major unique urban areas presently within the Denver SMSA will be encouraged to remain unique; that is, not to ultimately be allowed to expand and run together into nondescript, low density urban sprawl.

7. Major areas of ecological, environmental, agricultural, historic and archeological significance shall remain in a natural open or low density non-urban condition.

8. The Regional Housing Plan directed at the provision of a decent home for every family, and in particular, the low and moderate income groups, shall be an integral component of all Denver Regional Council of Governments Land Use planning activities and particulary in relation to transportation, employment opportunities, and social services.

PLAN POLICIES

The preliminary Land Development Plan consists primarily of a series of policy statements and a map representing those policies. The critical issues, however, revolve around the policy statements. The statements listed below are the latest version of an evolving series of statements originally postulated several months ago.

To review--we have defined Plan Policy to mean a *concise statement of policies relating to the influencing of the future growth and livability of the region, in ways felt to be in the public interest.*

The recommended preliminary plan consists of a series of seven explicit plan policies. The policies are, as earlier mentioned, designed as the explicit parameters upon which future decisions can be based. Those policies are:

1. *A population level below 2,350,000 should be encouraged for the Denver Metropolitan Statistical Area by the year 2000.*

The Denver Metropolitan Area has been growing very rapidly over the last decade. Present estimates show the likely adjusted growth rate for the entire SMSA for 1972 to be near 5%. That compares with a 1960-1970 simple annual average growth of about 3%. That magnitude of growth is beginning to clearly strain many local utility and public facility systems. Planning often becomes almost impossible when all energies are devoted to merely "keeping up" with daily increasing demands. Traditional forecasting techniques show a population of over 2.35 million people by the year 2000 for the SMSA. It is felt that a more effective utilization of resources would result from a lower population level.

<u>Implications of lower population level</u>:

1) Major new governmental mechanisms and incentives must be developed by the State to distribute the expected growth to other areas of Colorado. DRCOG and its member agencies shall promote implementation of such mechanisms.

2) High levels of effort to encourage new employers to locate in the metropolitan area should be discouraged.

3) State policy must be formulated concerning the distribution of growth throughout the state.

4) Many Open Space and Conservation Areas presently under extreme development pressure must be preserved.

5) The overall framework of recommended regional growth is more likely to be attained under a lower population level and pressure.

6) Major new federal and state investment in employment related facilities should be closely examined.

7) Plans for additional support facilities such as water, should be proposed in order to implement this policy.

2. *The Central Business District of Denver will be encouraged as the major high density core of business, cultural, governmental, commercial and residential activity. Major high density corridors east, west and south from the CBD shall be encouraged.*

Throughout the initial studies of the Joint Regional Planning Program, particularly the cultural synthesis study, it has been a policy that the amenities and unique characteristics of the Denver Central Business District would be maintained and reinforced. The CBD currently contains many functions unique to the SMSA area. Large scale commercial and business activity is one obvious asset. The Capitol of the State of Colorado exists in the CBD as does a major concentration of state and federal employment. Large scale recreational and cultural facilities also exist along with major accomodations for out of town visitors. Although other large activity centers throughout the region will begin to absorb some of the commercial and business activity originally only associated with the CBD, the CBD will remain as a center of many unique activities.

Two major high density corridors will be encouraged in central Denver. The corridors will be reinforced by provision of a fixed guideway public transportation system. Because of the high density and major activity centers located along the corridors, it is felt that the transit system will provide a major alternative to the automobile. A new exciting life style will be created for those individuals of the region who prefer a higher density living arrangement and its constant generation of activity. The intensification of existing areas will also help in the slowing down of major new residential development on the fringe areas of the region.

3. *Several major activity centers shall be encouraged in the Metropolitan Area.*

One major conclusion of the initial JRPP studies dealt with the recommendation of a series of major activity centers for the region. These areas were recommended for various reasons:

... They would become the major structural nodes of the urban form.

... They would allow the creation of centers of a large enough scale to generate a wide range of urban services and activities.

... They would encourage internal travel for those individuals who preferred to live and work in close proximity, hence, relieving regional travel demand.

... They would minimize dispersed suburban development by directing growth into centers.

... They would generate a choice of life styles for those individuals who prefer such a way of life.

... They would create high intensity centers worthy of a high level of public transportation.

... They would create centers where alternative internal transportation systems may be viable.

Those centers currently recommended are:

Center	General Location
Boulder	University of Colorado/Crossroads Shopping Area/CBD
Northglenn	Northglenn Shopping Area/Western Electric Front Range Denver Area
Arvada	Old CBD/Tri-Center Area
Federal Center	Federal Center/Community College/Westland Areas
Villa	Villa Italia Vicinity
Alameda	Alameda/I-225 Area
Denver CBD	CBD/Auraria/Skyline
Medical Center	CU Medical Center/Colorado-Colfax Area
Cherry Creek	General Cherry Creek Shopping and Residential Area
South Colorado	General Colorado Boulevard/I-25 Area/DU/ University Hills
Englewood	Englewood CBD/Cinderella City Shopping Center
Technological Center	General Area of Denver Technological Center/ Greenwood Plaza

4. *New, low density, residential growth should be encouraged only in locations contiguous to existing urban areas while recognizing local ecological, environmental or social concerns as they might affect the location of a specific development.*

Many of the studies conducted by the Joint Regional Planning Program taken as a whole, suggest that new development should essentially be discouraged from a northeasterly direction. Much of the region's major air pollution is found in the Platte Valley to the north of the Region. Major amounts of the best agricultural soil in the Region also exist in the Northeast sector of the Region. Major flood plains and aquifer recharge areas also exist in that area.

Major development is also to be discouraged in the direct westerly direction from the Metropolitan Area. Areas of extremely high winds exist along the foothills areas, as well as slope conditions not propitious for large scale residential development. Water, sewer, and other community services are hard if not impossible to provide. The foothills and major mountain areas of Colorado exist as one of the most beautiful amenities in the Region. They should be kept in a natural state.

Development should remain contiguous with existing urban areas to minimize disjointed and scattered public facility costs and development. Haphazard development in areas several miles from the fringe of existing urbanization although initially cheaper for the developer and buyers, ultimately must be provided with urban facilities and amenities that cost more to provide over a large area. That cost is ultimately absorbed by public funds.

Development in a non-contiguous and haphazard manner makes the provision of public transportation facilities difficult and costly, adding to the number and length of auto trips from those areas. The lengthening of these trips causes increased levels of air pollution as well as increased investment in public roads.

5. *New industrial development should be encouraged only insofar as suitable locations could be found where environmental hazard potential can be effectively controlled or minimized. Major new employment concentration of any type should be closely analyzed as to their total regional and state impact, which analysis should carefully consider the adverse costs, such as peak hour travel, work trips, and public service costs.*

New industrial development should be discouraged from locating in the Platte Valley. Some of the Region's worst air pollution is funneled through that area. New polluting sources will not help attempts to ameliorate that pollution. Much of the Valley is located in the standard project flood area of the Region. To avert potential loss of property and life, those areas prone to flooding should be protected from development.

Besides pollution considerations, many areas of the region are environmentally sensitive to large scale industrialization. Industries and employment centers requiring large amounts of natural resources, i.e., air, water, should be closely examined as to their total effects. Industries with large traffic generation, i.e., warehousing, goods movement, should be examined as to their effects on the surrounding area. Major new employment concentrations, because of their effect on regional growth and development, should be closely examined.

6. *Major unique urban areas presently within the Denver SMSA will be encouraged to remain unique; that is, not to ultimately be allowed to expand and run together into a nondescript, low density urban sprawl.*

In order to retain major community identification, and the unique character of many smaller communities within the region, a specific policy for retaining these distinct communities is being recommended. This policy will take the form of discouraging sprawl interstitial development which, in effect, will begin to fill in the landscape between such communities. This policy often will take the form of opposing annexations carried out by individual communities. It may also take the form of discouraging the extension of urban services to more rural areas.

7. *Major areas of ecological, environmental, agricultural, historic and archeological significance shall remain in a natural open or low density non-urban condition.*

Major areas of the region under various levels of criteria should remain in an open state. For our purposes, we will define these areas as:

- Climate Hazard Areas
- Unsuitable Soil Areas
- Aquifer Recharge Areas
- Drainageways
- Excessive Slope
- Fault Zones
- Forrested Areas
- Areas Between Distinct Urban Entities
- Historically Rich Areas
- Archeologically Significant Areas
- Prime Agricultural Land

Many of these areas have already been markedly violated in terms of development. This policy suggests that no new development should be encouraged in these areas.

rae
12/18/72

APPENDIX B

GROWTH-INDUCED IMPACTS ON THE REGION'S ENVIRONMENTALLY SENSITIVE AREAS

Table of Contents

APPENDIX B

GROWTH-INDUCED IMPACTS ON THE REGION'S ENVIRONMENTALLY SENSITIVE AREAS

Wastewater collection and treatment is one of several basic services local government provides to serve the needs of its citizens. Planning to accommodate a future population and its need for wastewater treatment and disposal is a prudent and responsible function exercised by local governments. Construction and operation of these facilities in accordance with plans to accommodate future growth must be considered a contributing factor to the environmental consequences of future growth. The same is true for other services such as highways, schools, and water supply. On a regional basis, it is rare that the provision or lack of a single "municipal" service stimulates or constrains regional growth, and can be considered the dominant factor in growth-related environmental impacts. It can, however, influence development patterns. The purpose of this section is to assess the impacts of changes expected to occur in the region as a result of the population increases and resultant development patterns projected for the year 2000.

CLIMATE

Construction activities to accommodate further urban expansion within the region will be a factor in the severity of Chinook wind episodes. Ground surfaces disturbed by construction provide particulates that can be carried downwind into developed areas. The local severity of particulate-laden Chinooks depends on such factors as the area of disturbed ground surface, soil characteristics, wind velocity and turbulances and downwind land uses. The significance of this impact ranges from that of a nuisance to that of a hazard to traffic, equipment, structures and crops. This will be a long-term, seasonal impact occurring at many sites scattered throughout the region's urban expansion areas.

Further commercial and industrial development is expected in the high wind corridors of the South Platte River and Clear Creek Valleys. Thus, the overall potential for wind damage will be increased in these valley areas. The significance of individual problem sites is not great on a regional scale. However, the cumulative effects of many sites over a long period of time presents a moderately important class of impacts which warrants consideration in the region's land-use decision-making processes.

Early morning traffic problems created by radiation fog will intensify in significance as traffic volumes continue to respond to suburban growth. The problems will likely range from simple traffic slow-downs to chain-reaction accidents involving property damage, injury and potential loss of life.

GEOLOGY

Grading of undulating natural landscapes for urban expansion can drastically modify landforms, change drainage patterns and alter visual appearances. The extent and quality of landscape changes will be determined at the scales of individual and cumulative development sites. The changes will involve such factors as the extent natural conditions, the types and sizes of projects, and the manner in which the projects are designed to fit into the landscape. The grading impacts of projects in an area can be significant on a local or sub-regional level where massive cuts and fills are made for roadbuilding and hillside terracing, and in floodplains where protective devices such as channelization, diversions and in-stream structures are constructed. From a regional perspective, these large-scale activities are likely to have cumulative impacts on water quality as discussed under "Soils" which follows. Visually, however, gross landform characteristics on the regional level will not be radically altered.

Urban development such as that which has occurred near White Rocks in the Boulder area will occur near other unique and significant geologic structures and formations. Development in close proximity to many of these structures and formations will pose damage potentials of varying significance through over-use and vandalism.

The region's geologic hazards to development are generally local in nature and do not pose any region-wide threats to urban expansion. However, the bentonitic clays, landslide areas, and, to a much lesser extent, faulting and its potential seismic activity can affect individual projects. Assessments of potential, project-specific impacts are usually left to local jurisdictions, project proponents and the interested public where they are mitigated within the framework of local regulations. No efforts have been made in this study to evaluate the effectiveness of the region's local geologic safety regulations.

SOILS

The regional significance of particulate wind transport during Chinook events was discussed under "Climate." Another consideration of wind erosion is that of the current drought and its effects on present and future agricultural productivity. Current reports are that many farmers on the Colorado Plains are turning under their winter wheat crops (Reference). The exposed soil, lack of rain and high winds are contributing to severe dust storms which are causing significant damages to structures and equipment, and losses of valuable top soil. The short-term effects of the crop and capital investment losses, and the long-term effects of the crop and capital investment losses, and the long-term effects erosion-related production potential losses on the region's economy have yet to be assessed. Implications of a continuing drought on regional land use trends was discussed earlier in this section under "Conversion of Agricultural Land in the Denver Region".

In terms of soil loss, water erosion is usually a more significant regional impact of urban expansion than wind erosion. Construction sites left exposed to precipitation and run-off experience sheet erosion, rilling and, at times, gullying depending on the type and rate of precipitation, the area of exposed soils, soils characteristics, and topography. Soils transported from construction sites via run-off can clog drainage improvements; contribute to streambank scouring, turbidity, siltation and sedimentation in the drainage net; increase receiving water temperature; and reduce chemical and biologic water quality. These impacts can be significant well beyond the general vicinity of the construction site and its drainage basin by contributing to cumulative water quality problems created by suspended, deposited and dissolved materials from the region's other point and nonpoint water pollution sources.

HYDROLOGY

Urban expansion can impact sensitive hydrologic features including wetlands/marshes, floodplains, groundwater, and lakes in three main ways. These include: (1) encroachment into or elimination of the feature, (2) change in the amount and distribution of water flowing to or through the feature, and (3) change in the quality of water flowing to or through the feature.

Construction of buildings, roads and bridges together with regrading for development can result in encroachment into or elimination of wetlands/marshes, lakes and natural floodplains. The proximity of development can affect both the flora and fauna of the hydrologic element. Development can alter the extent of the flood hazard area limits through alteration of the conveyance capacity of the natural watercourse. Unwise occupation of the floodplain can seriously increase the potential for flood damage.

Development can cause an increase in the base flow of water reaching wetlands/marshes, lakes and floodplains, and the flora and fauna may be affected. Lawn irrigation return flow, interception of the groundwater by storm and sanitary sewer systems, and leaky water distribution systems may be responsible for the increased flow. Development may cause a decline in the recharge to the groundwater table through occupation of a recharge area such as that in the southwest portion of the region through decreasing infiltration because of impervious cover, and through elimination of agricultural irrigation in the area. Development tends to increase the peak rate, volume and frequency of flooding both within and without the floodplain. The extent of increase tends to be larger for the more frequent floods than for rarer ones. These changes can cause greater erosion within steep floodplains and may affect the vegetation that can be maintained.

Development is likely to produce a decline in water quality reaching the hydrologic features. This can result from automobile wastes, fertilizers, pesticides, sewage, and sediment. Poor water quality greatly speeds up the natural entrophication process of lakes, and can affect the flora and fauna of lakes, wetlands/marshes and floodplains.

The various hydrologic features can also affect development. Any floodplain development can be unwise, particularly along those stretches of the upper portion of Bear Creek, Clear Creek and the upper portion of the South Platte River which experience periodic flashflooding. The aesthetic quality of lakes may provide the interesting focal points around which developments are planned. A reliable groundwater supply may be one consideration in the feasibility of particular developments. Wetlands/marshes within the study area are generally not viewed as assets, but may affect development through creation of the need for drainage projects to dry them up.

BIOLOGY

Stream Channelization

Conversion of rural lands to urban uses typically requires flood control measures for local watercourses. Physical structuring such as channelization is one of the most common measures. Watercourse straightening and the resulting new streambeds reduce habitat diversity. Removal of riparian vegetation, paving of stream banks and colonization by weeds also severely reduce habitat.

Upstream Conversions of Land to Urban Uses

Removal of groundcover, grading and construction in watershed areas will lead to a short-term degradation of the aquatic environment. As discussed under "Soils" earlier in this section, erosion from disturbed construction sites leads to siltation, increased suspended solids, turbidity and warming effects upon streams. Aquatic habitats are affected when a channel's biologically diverse rough bottom surface is filled in and covered with silt, the silt eliminates the physical niches necessary to benthic organisms, thus eliminating the organisms themselves. The fish and other higher animals which feed on the organisms are then reduced in numbers or eliminated from the affected area. Upstream developments are of particular significance within the basins of Sand Creek and Clear Creek.

Industrial Activities near the Aquatic Environment

Extensive gravel resources are found along many of the major watercourses. Aggregates are the major type of resource consumed in construction activities and as such, the demand for them will continue at rates reflecting the rate of urban expansion. Continuing and future aggregate mining is likely to entail channel disturbances and modifications, streamside vegetation removal and discharges of wash water from gravel processing operations. The potential for impacts on the aquatic and riparian environment varies in proportion to the extent of disturbances and the type of industrial process.

Disruption of Riparian Corridors and Aquatic Habitat

Riparian vegetation zones are valuable transitional areas between aquatic and terrestrial environments. They also serve as movement corridors and cover while supplying food for wildlife. Construction and development across riparian zones severs the continuity of this habitat thereby disrupting wildlife movements. Development around pond and marsh areas often disturbs the local habitat quality. Physical disturbances also affect the local environmental quality and carrying capacity.

Disturbance of Forest and Brushland Areas

Development in foothill areas typically consists of tree-cutting, clearing, road construction and other activities disruptive to natural conditions. The opening of rural and wild lands for residential and increased recreational uses creates pressures on wildlife and their habiclearing, road cutting and other activities disruptive to natural conditions. The opening of rural and wild lands for residential and increased recreational uses creates pressures on wildlife and their habitats. Development along the foothill and mesa areas may infringe upon critical wintering areas typically used by deer and elk. Some curtailment of deer and elk feeding range may occur in the eastern boundary near Cherry Creek Reservoir and to the west in Douglas County. Animal and bird migrations through the lower foothill area may also be disturbed.

Development near Unique Habitat Areas

As indicated on Map F, several areas have been recognized as ecologically significant due to unique geologic formations, soil types, plant and animal communities and other factors. Development and recreation pressures on these areas may not only degrade the habitats or affect the surrounding environments, but which also cumulatively reduces the overall environmental quality of the région. Areas of particular concern due to urban expansion as noted by comparisons of the Projected Land Use By the Year 200 Map (Map I) against the Biologically Sensitive Areas Map (Map F) are: (1) the Nature Conservancy in northwest Denver, (2) the Ken Caryl-Johns Manville Ranch, (3) the Marshall Mesa and (4) the White Rocks area near Boulder.

Increased Fire Hazard

Fire hazards are most critical on slopes where a fire can spread twice as fast on a slope of 30 percent as on level ground. Gullies and canyons associated with steep slopes present a severe fire hazard during dry weather due to the combined funneling and updraft effects. Human activities greatly increase the wildfire potential. Building on steep slopes, residual slash or felled timber, logging debris and other inflammable litter increase this potential in areas where the existing wildfire hazard is high. Careless or accidental ignition by tourists, residents and faulty equipment may cause a great deal of damage to vegetation and destroy wildlife habitat. In some cases, road construction and maintenance may increase fire hazard as much as new housing on steep slopes. There is a tendency for access routes to homes to be more of a problem than housing itself. Roadcuts frequently induce landsliding and drainage problems. In addition, during wildfire conditions, narrow and winding roads may actually hinder the movement and efficiency of firefighting equipment.

ENERGY

The 1975 population of the Denver Region constituted about 57 percent of the population of the State of Colorado. By 1985 it will constitute perhaps 60 percent, and by 2000 about 54 percent of the state population. The Denver region's share of statewide energy consumption is estimated to be on the order of 64-68 percent at the present time. natural gas shortfalls amounting to 15-20 percent within five years are expected to begin in the Denver region during 1978-79. The demand for Natural gas by the Denver region may adversely affect the rural areas of Colorado as rural areas are dependent on liquid propane which is manufactured from natural gas. There will be an increased reliance on and demand for electric power. After 1980, if scheduled power plants are delayed significantly, some brown-outs or load reduction and shedding will occur. The increased demand for electrical power will probably be met with coal-fired power plants which will necessarily increase Colorado's coal production. Consequently, beginning in the 1980's, conflicts will arise between municipal and agricultural water users in the Denver region, and energy industries over available water supplies. Adverse air and water quality impacts are also likely.

Regional demand for petroleum-based fuels will increase with increased population. This increased demand will be limited to some degree by increased vehicle fuel economy and higher fuel prices. Although there will still be a net increase in consumption, petroleum-based fuels will be a smaller part of overall basic fuel use.

HISTORICAL FEATURES

Denver is an old frontier city which contains many points of historical interest. So far, only the outstanding examples of period architecture and historical sites have been officially designated historical landmarks. However, there are still many old structures that merit recognition and preservation. Individuals and businesses are becoming increasingly active in converting and restoring historic structures for use as homes and places of business. Population and economic growth will further accelerate the demand for historically valuable structures. Conversion and restoration activities have the potential to benefically as well as detrimentally alter the characters of historically valuable neighborhoods and districts. Character alteration also results from the introduction of contemporary structures and uses. Both public and private redevelopment activities in old areas can alter the significance of landmark buildings which provide focal points and help give the areas their unique identities. If the area around a landmark building is redeveloped with contemporary structures and uses, the significance of the landmark changes from that of a focal point of an historic district to that of a museum relic isolated from its historic context. This impact has already occurred around such structures as the State Capitol Building in Denver. Once the dominant feature in old Denver, it is now obscured from view in the surrounding area by uncomplimentary concrete and glass, multi-stored architecture. Increasing air pollution will contribute to the already high costs of restoration and maintenance of old structures.

AESTHETICS

Growth in the Denver region could lead to a degeneration of many qualitites which have created Denver's attractiveness and desirability. Some of the ways these qualities may be adversely affected by population growth and urban expansion include:

(1) Potential degradation of wetlands and other natural areas due to population pressure to develop new recreation areas;

(2) Disappearance of sensitive wildlife with subsequent replacement by species tolerant to humans, some of which may become nuisances;

(3) Conversion of natural, open space environments to urban systems at a rapid rate which may be based on short-term considerations;

(4) Development near surface waters which may limit public access;

(5) Loss of public viewing vantage points to road layouts, developments and artificial landscaping;

(6) Poor road layouts hindering public access to scenic areas;

(7) Existing and new roadways, viaducts and bridges divide Denver into many indistinguishable parts thereby diminishing resident's orientation of their region;

(8) Concentration of vehicular traffic along a few transportation corridors creating zones of degenerated air quality and increased ambient noise levels;

(9) Increased urban sprawl necessitating longer travel distances for daily activities;

(10) Conflicting interpretation of the public interest, e.g. provision of municipal services, increases in the tax base, unlimited military use etc. versus open space, recreation opportunities and wildlife habitats etc. having effects on the aesthetic quality of the region; and

(11) Urban sprawl leading to inefficient resource and services allocations which in turn contributes to a consumptive life style.

OUTDOOR RECREATION SITES

Regional growth will require the development of lands already acquired by park and recreation agencies and will likely require the acquisition and development of even more recreation land before the year

2000. If the growing needs of the populace are not met with more facilities, existing facilities are likely to be overused and damaged. The visual effects and recreational opportunities of numerous, well-located and easily accessible recreation areas can well enhance the social quality of life in the urban expansion areas. Park facility vandalism will likely continue throughout the region in those areas having a high percentage of children and young people. This will be especially true in new suburban areas where there is a general predominance of young families. As these suburban areas age, the populations should begin to mature and the incidences of vandalism should corollatively decrease.

LAND WASTE TREATMENT SITES

Until a decision is made on the West Adams County sludge disposal site, the Lowry Bombing Range sludge disposal activities will continue and existing problems could worsen due to the high sludge application rates. However, the anaerobic digestors now under construction will reduce sludge volumes by a maximum of 50 percent which can significantly reduce the short-term possibility of a worsening situation. If the West Adams County site is not approved due to some unforeseen environmental or legal problems, some new disposal scheme for the Lowry site might be adopted which could continue the present controversy. This controversy has resulted from a basic conflict between the established disposal use and the adjacent and growing residential uses.

TRAFFIC

Continued dependence on the automobile as the primary mode of transportation is inevitable in the near future while relatively affordable supplies of petroleum fuels are available. The impacts related to automobile dependence such as low density or sprawl development, congestion and high noise levels in the central business district (CBD) and smog throughout the region will continue to worsen. The commute hour overload situation will also continue and, in some areas such as the CBD and suburbs near the CBD, it will worsen. New highway construction will temporarily alleviate traffic problems by eliminating some traffic flow constraints and providing new thoroughfares. These actions will increase the region's total traffic volume capacity which will enable it to accommodate further suburban growth in patterns and of densities similar to those presently existing. Further suburban growth of this type will absorb the new traffic capacity in a relatively short period of time and a new traffic remedy will be required. The Federal Urban Mass Transit Administration's denial of funds for a regional transit system eliminates the possibility of a fixed rail system for the time being. This will necessitate the use of the Regional Transit District's bus fleet in any attempts to provide the region with a mode of transportation to that can compete with the automobile.

Such things as carpooling and vanpooling will reduce the number of cars on the road by increasing the average number of people being carried in each vehicle. The Regional Transit District has a bus system which provides a good alternative to travel by automobile only. A fixed guideway type of facility has been studied in an alternatives analysis and has been shown to be no more efficient in attracting people from their autos than a comprehensive Regional Transportation System comprised totally of buses.

APPENDIX C

CLEAN WATER PLAN

Clean Water Plan

Denver Regional Council Of Governments

CLEAN WATER PLAN

DENVER REGIONAL COUNCIL OF GOVERNMENTS

CLEAN WATER PROGRAM

APRIL 1977

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CONTENTS

SECTION I

INTRODUCTION

The passage of the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500, represented a major step by the nation to insure future generations of the highest level of water quality possible. Prior to this time the federal government had neither mandated strict enforcement of water quality standards nor provided the large amount of construction funds needed to overcome years of abuse of the nation's streams and waterways. Public Law 92-500 provided a mechanism for planning, design, and construction of treatment facilities, as well as regulatory measures for control of point source pollution through the National Pollutant Discharge Elimination System (NPDES).

The Act identifies a number of planning programs which should be initiated at various levels of government to begin the process of water quality improvement. In order to maximize efficient utilization of resources, Section 208 of the Act established an areawide approach to planning for the abatement of pollution. Section 208 provides that a local plan based upon a comprehensive and integrated approach to water pollution abatement be designed which insures that the goals of the Act are achieved within the framework of local needs and requirements.

The U.S. Environmental Protection Agency is charged with the implementation of the federal program. In turn, PL 92-500 requires that the Governor's Office assume the responsibility of certifying areawide 208 plans throughout the state. Upon approval by the Governor, the plans will be forwarded to the EPA which is the major funding source for water quality management programs.

The Clean Water Plan presents the areawide water quality management plan selected for the Denver metropolitan region. Once officially adopted by DRCOG and accepted by the state and EPA, it will form the basis for future wastewater facilities with respect to sizing, staging, location, and treatment levels. In addition, the institutional management regarding management and planning for wastewater facilities will be determined. It is the intent of this document to present the recommended plan in a manner which can easily be understood by all persons or agencies concerned with water quality.

The Clean Water Plan for the Denver metropolitan area is the result of cooperative efforts involving citizens' groups; wastewater treatment management personnel; professional consultants; federal, state, and local governmental agencies; and the Water Quality Management Task Force. The Task Force, comprised of citizens with varied interests and points of view, was formed by DRCOG to oversee the progress of the program, select consultants, and review and approve major plan recommendations. Plan alternatives and the recommendations considered by all of these agencies and groups are presented in the DRCOG Clean Water Program Technical Report Draft of March 1977.

The Denver Regional Council of Governments (DRCOG), because of its regional perspective in the history of water quality planning for the area, was designated the "Areawide Waste Treatment Management Planning Agency" by Governor John Vanderhoof in July 1974 for the five-county Denver metropolitan area. This designation insured that a comprehensive water quality study addressing each of the various water pollution sources and its impact on water quality would be conducted for the entire region.

Beginning in March 1975, DRCOG began putting together the 208 planning process needed to meet the requirements of PL 92-500. The 208 Clean Water Program had a two year completion requirement from the time the planning process was formally initiated. For the Denver area program, this date was identified as July 1975 for initiation. The two-year program was funded by the U.S. Environmental Protection Agency at a funding level of $1.29 million.

PL 92-500 sets forth the following specific water quality goals for the nation: (1) "It is a National goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water be achieved by July 1, 1983," and (2) "The National goal that the discharge of pollutants into navigable waters be eliminated by 1985."

The DRCOG 208 Clean Water Program evaluates these goals and their attainability in the Denver area with respect to financial, environmental, social, and economic impacts. The Program addresses these goals as well as the existing and potential uses of clean water in trying to determine what is desirable and attainable in the region.

SECTION II

WASTEWATER TREATMENT FACILITIES

FACILITIES PLANNING

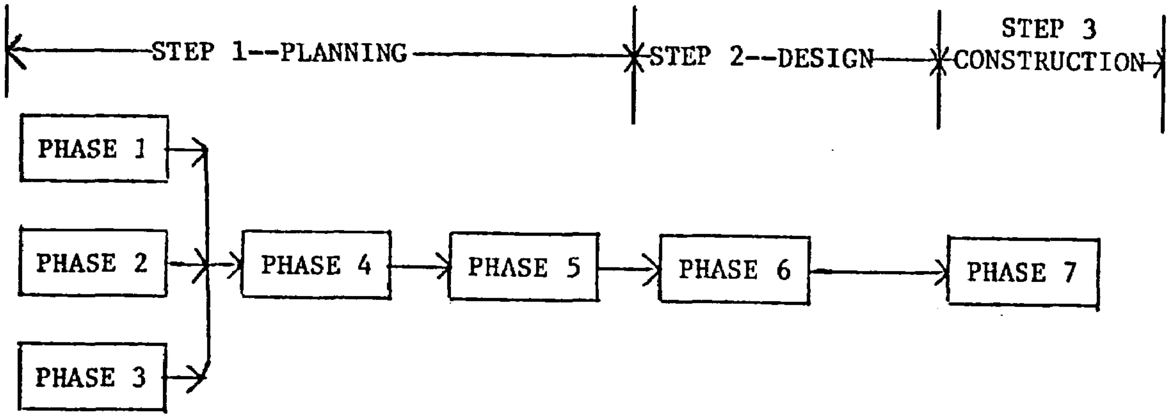
Section IV presents a general discussion of the process under which management and planning agencies operate to accomplish 208 water quality planning. The U.S. Environmental Protection Agency requires that 201 studies conducted by management agencies and 208 studies conducted by planning agencies be coordinated and consistent. It is within the 201 facility planning studies and not the 208 areawide planning process that site specific issues dealing with implementation are addressed.

In the metropolitan Denver area there are 13 ongoing 201 facility planning studies. These studies are extremely important as they will provide the basis for determining the final sizing and staging of municipal wastewater treatment and interceptor facilities. DRCOG has developed guidelines to ensure facility planning consistency with the areawide Clean Water Plan. Consistency between the two plans should be established as early as possible in the 201 process. This consistency would normally take place when basic planning elements such as population, land use, facility requirements, and alternative treatment strategies are being outlined for the 201 study.

Most facility planning, design, and construction takes place through a seven-phase process. Although within certain facility planning efforts some phases are more important than others, each of the following phases must be incorporated into the 201 process:

1. Assess current conditions.
2. Assess future conditions.
3. Develop effluent requirements.
4. Develop and evaluate alternatives.
5. Select plan.
6. Prepare design of treatment works.
7. Make arrangements for implementation.

These phases are divided into a three-step process within the 201 program as shown in the following schematic:



Step 1, dealing with planning activities only, relates to the first five phases; Step 2 (Phase 6) is the design of the facility; and Step 3 (Phase 7) is the implementation or construction of the facility. The Clean Water Plan and Program will provide data to the 201 agencies for the first four phases of Step 1. Information pertaining to population, land use, facility requirements, and alternative treatment strategies developed at the regional level will provide basic information for 201 facility planning.

Phase 1--Current Conditions

Assessing the current situation is a joint responsibility of the 201 and 208 programs. The process includes the following elements:

1. Planning area description.
2. Demographic data.
3. Water quality data.
4. Existing environmental conditions.
5. Existing wastewater flows and treatment systems.
6. Infiltration/inflow estimates.

The Clean Water Plan delineates on Figure II-1 a general planning area for the 201 planning studies. For areas not shown on the figure, the 201 planning areas conform to the existing service area of the management agency. The 201 agencies may need to refine the planning area boundaries according to their service agreements working with the DRCOG. The planning area delineations will be subject to annual revision as institutional and service patterns change within the 208 Study Area. Although DRCOG has developed areawide information for each of the planning elements, that information needs to be detailed according to the local situation for adequate evaluation by the 201 agencies. Detailed implementation information is required in order for the 201 agencies to proceed with Phases 6 and 7.

Phase 2--Assess Future Conditions

Assessment of future conditions is dependent upon close coordination of the 201 and 208 programs. The Clean Water Plan utilized forecast allocations of population and land use within which the areawide plan was developed. The population allocations were adopted by DRCOG in August 1976 for the expressed purpose of conducting regional functional planning. The

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adopting resolution, within which the Clean Water Plan has been developed, provides flexibility in use of local projections for facility planning in relationship to the population allocations.

In general, 208 planning has been closely coordinated with 201 planning to insure consistency of base information and alternatives being evaluated by the two planning programs. Population forecast allocations for facility planning can be based on one of three options: (1) The 208 planning population allocations adopted by DRCOG as amended from time to time, (2) two or more population projections from any source as long as one of the projections is the adopted 208 population allocation, and (3) a single projection other than the adopted allocation with agreement of the 208 agency. If the third option is selected, the population projection preferred by the 201 agency will be submitted to the 208 planning agency together with a technical justification of the projection including methods, data, and assumptions used in its preparation. The 208 agency will determine consistency of the selected projection for 201 facility planning.

It is anticipated that each 201 planning study will establish site specific flow projections that will result in wastewater flows and loads specific to the area which will be incorporated into the design and construction of the facility. Wastewater flow projections in this report are based upon areawide data. These projections, which are discussed further under Treatment Levels, are based upon a flow determination of various factors dealing with (1) residential flow, (2) industrial flow, (3) commercial flow, (4) public land flows, (5) parks and recreation flows, and (6) infiltration/inflow. It is anticipated that each 201 agency will make its own determination of these various flow factors and their impacts on the wastewater facilities in their area. The Clean Water Program Technical Report provides certain guidelines and averages which an agency could utilize if better data at the local level is not available.

Phase 3--Effluent Requirements

The quality of effluent discharge from the proposed facility will be reflected in the NPDES discharge permit issued to the agency constructing the facility. NPDES requirements normally relate to the 1977 secondary treatment requirements as well as higher requirements if the facility is located on a water quality limited stream segment. The development of effluent limitations is a function of the 208 Plan with concurrence of or revision by the State Water Quality Control Commission. The limitations developed by the 208 study will relate to the 1983 water quality goals where attainable. Facility planning during the past several years has concentrated on meeting the instream water quality conditions required for the attainment of a warm or cold water biota. When the state certifies the Clean Water Plan, a stream classification will be established upon which future NPDES permits will be issued. This classification system is an extremely important element upon which the water quality management plan is based.

Phase 4--Develop and Evaluate Alternatives

Development and evaluation of plan alternatives will be coordinated with the 208 program. Within the framework of regional 208 planning are alternatives for treatment facilities that may have a direct impact on 201 facility planning efforts. However, the level of detail in the 208 analysis is insufficient for a final 201 facilities plan. The 201 alternatives will be evaluated in detail for pollutant removal effectiveness, costs, and environmental affects for alternative sites in the general area designated by the 208 Plan. Regional water quality impacts from point sources on instream water quality will be identified in the 208 planning process for input into the 201 alternatives.

The 201 Plan should refine and update the Clean Water Plan as necessary to achieve the degree of accuracy required through site specific facility planning studies. The 201 Plan must be more specific than the Clean Water Plan on alternatives relating to industrial use of municipal facilities, flow and wastewater reduction measures, economic studies of the most cost effective location and size, sludge disposal alternatives, land application or refuse alternatives, and revision of wasteloads resulting from changes in discharge locations. Other elements relating to 201 planning deal with phasing of construction, obtaining sufficient land and rights-of-way, and provision for future planning flexibility.

Phase 5--Select Plan

Final plan selection is the responsibility of the 201 agency. Public meetings and hearings are required to obtain the views of the public concerning site specific alternatives. The 201 environmental impact statement provides a method for incorporating site specific and regional environmental impacts necessary for final plan selection. If the 201 Plan is not consistent with the Clean Water Plan, the Clean Water Plan should be amended based upon the detailed analysis done within the 201 planning process.

Phase 6--Design of Treatment Works

Preliminary design of the treatment facility is strictly a function of the 201 agency. It is not anticipated that the Clean Water Plan will be affected by the final design of a facility.

Phase 7--Arrangements for Implementation

Guidance for making arrangements for management implementation of the 201 Plan is provided within the Clean Water Plan. However, specific institutional and financial arrangements for the new facilities must be made by the management agency which has final implementation responsibility.

POPULATION AND LAND USE

The rate and type of growth experienced by a region can impact the quality of its water resources. This impact occurs in the form of point and non-point sources of pollution. While Denver area growth has not been especially concentrated in areas unsuited for new development, it has generated concern over the effect of urban sprawl and development on water quality and other undesirable trends dealing with exceeding treatment capacities and interceptor facilities. These concerns reflected the need for regional approaches to growth plans and policies.

The most recent policy action by DRCOG was the adoption of a development policy allocating the regional population forecast to subareas. This is the first regional attempt to allocate development to small areas and has been used to determine the need for wastewater facilities. A new unit, the Urban Service Area, was defined for this allocation process.

These Urban Service Area allocations were adapted to basin and plant service areas. The first step in the reallocation created a set of geographic equivalencies between basins and Urban Service Areas. This provided a preliminary set of 2000 allocations which assumed uniform densities across basins within an Urban Service Area. The 1975 data was compared to this allocation and the 2000 data was adjusted where necessary. Staging between 1975 and 2000 was then made in a straightforward manner with Urban Service Area allocations serving as control totals for basins. Table II-1 summarizes the allocations by basin.

TABLE II-1. Reallocation of Adopted Regional Subarea Population Allocations to Basins, 1975-2000.

Basin	Current	Short Term			Long Term
	1975	1980	1985	1990	2000
St. Vrain	43,240	58,930	59,430	68,300	87,300
Boulder Creek	99,830	107,940	117,730	127,780	144,290
Coal Creek	15,990	23,620	29,980	36,860	41,400
Big Dry Creek	28,750	43,230	55,100	68,270	98,060
Lower South Platte	21,010	45,635	54,860	65,090	103,570
Clear Creek	305,840	336,900	354,740	378,560	417,650
Sand Creek	169,640	186,120	211,264	234,659	306,600
Cherry Creek	342,310	364,950	386,060	408,710	485,820
Lakewood	266,290	263,800	265,190	265,950	273,820
Bear Creek	57,240	76,080	97,950	118,940	156,290
South Metro	134,200	159,140	195,650	231,960	298,470
Upper South Platte	7,710	9,759	12,450	15,350	21,700
Plum Creek	8,140	10,930	13,240	15,940	20,580
Box Elder Creek	950	1,100	1,200	1,400	1,700
Eastern Plains	4,150	4,600	5,600	6,600	8,200
Totals	1,505,290	1,692,725	1,860,444	1,944,369	2,465,450*

*This figure includes population projections outside the five-county study area.

To forecast future sizing of existing or proposed treatment facilities requires resident population projections for the area tributary to the facility. Table II-2 shows the plant service area population allocations used in the second phase analysis and the final Clean Water Plan. For the most part these figures are directly related to combinations of Urban Service Area and/or subarea allocations. A limited number of small service areas required additional allocation based on expected patterns of growth within a small portion of a basin or Urban Service Area.

TABLE II-2. Population Allocations By Sewer Service Planning Area, 1975-1985-2000.

Sewer Service Planning Area	1975	1985	2000
Englewood/Littleton	137,000	190,000	276,000
South Lakewood	16,800	19,000	22,800
MDSDD #1(2)	1,050,000	1,020,000	1,240,000
Golden	-	18,600	26,000
Sand Creek	11,500	123,000	194,000
South Adams County	28,600	39,600	47,300
Brighton	11,900	18,000	25,000
Big Dry Creek(3)	4,800	60,900	143,000
Boulder	94,600	107,000	130,000
Longmont	34,800	46,300	67,400
Erie	1,520	1,800	2,700
Lafayette	6,990	10,200	14,000
Louisville	4,440	10,000	13,600
Glendale	3,700	8,700	8,700
Evergreen	2,000	3,470	4,870
Genesee	-	1,250	2,650
Kittredge	500	720	1,010
Lake Eldora (1)	-	-	-
Lyons	850	1,060	1,410
Morrison	450	520	665
Mountain Water and Sanitation District	140	210	310
Nederland	600	750	900
Niwot	2,500	3,200	4,600
West Jefferson County	1,000	4,300	6,050
Bennett	900	1,700	2,300
Byers	400	700	1,000
Deer Trail	400	400	400
Strasburg	1,000	1,500	3,000
TOTAL	1,417,390	1,692,880	2,239,665

(1) Ski resort with no overnight lodging.

(2) Assumes Golden on line by 1-85, Lower Thornton going to Big Dry Creek by 1985, and the total service area flow for Sand Creek with the exception of Aurora Westerly Creek being handled by the Sand Creek Plant for 1985 and 2000.

(3) Assumes Thornton on line by 1985 and Broomfield phased-out by 2000.

TREATMENT LEVELS

The primary goal of the Clean Water Program was to evaluate the achievability of fishable/swimmable waters in the 208 Study Area and to provide information upon which future water quality classifications can be based. To accomplish this goal an inventory of existing conditions and projections of costs for upgrading water quality in various stream reaches were made.

In determining the treatment levels necessary to meet stream classification requirements, point source flows were determined on an average daily basis for 1975, 1985 and 2000 (Table II-3). These flows were developed on a regional basis and should be refined by the 201 management agencies. The annual average residential unit flows were initially estimated by computing the per capita value for a predominantly bedroom community whose wastewater volume is measured by the Metro district. This value was compared with two other residential flow studies, one from Boulder and the other performed in the midwestern United States. Also, to check domestic water consumption minus the effects of lawn watering, winter water use volumes were obtained from various water departments. During the winter months, life sustaining water uses--cooking, washing, drinking--consume about 7.5 percent of the water supply. The remaining 92.5 percent returns to the sewers as wastewater. The estimated home use minus irrigation value for the Denver Water Board service area is approximately 60 gpcd based on these assumptions with an annual average of 65 gpcd.

Unit wastewater flow values by land use category were established by applying measured values in the greater metropolitan Denver area and comparing them with other published data to identify any gross errors. The unit values were also checked against available water records from the Denver Water Department and several other agencies. The industrial and transportation, communications, and utilities unit per acre flow was computed based on a telephone survey of the industries in the North Washington Water and Sanitation District (Commerce City area). The resulting value was modified by determining a weighted average of heavy industry to the warehousing operations in the area. The weighted unit flow value was again modified by the average ratio of industrial to transportation, communication, and utilities acreage in the area.

The major municipal service areas in the DRCOG 208 Planning Area are shown in Figure II-1. All of these facilities, except for the City and County of Denver's Northside Plant, discharge effluent of at least secondary quality. The Denver Northside Plant discharges primary treated effluent to the Metro Central Plant where it undergoes secondary treatment prior to discharge to the South Platte River.

TABLE II-3. Point Source Flows by Treatment Facility

Facility	1975	1985	2000
Englewood/Littleton	14.5	20.9	32.0
South Lakewood	1.9	2.2	2.5
MDSDD#1(2)	132.0	139.0	173.0
Golden	--	3.3	4.1
Sand Creek	1.1	13.5	21.4
South Adams County	2.0	3.8	6.8
Brighton	1.5	2.1	3.0
Big Dry Creek(1)	0.6	6.7	16.9
Boulder	11.2	15.2	18.0
Longmont	5.0	8.2	11.2
Erie	0.1	0.4	1.0
Lafayette	0.6	1.3	2.0
Louisville	0.0	1.3	2.0
Glendale	0.7	1.3	1.4
Evergreen	0.25	0.64	0.96
Genesee	--	0.15	0.50
Kittredge	0.01	0.08	0.10
Lake Eldora	0.01	0.01	0.02
Lyons	0.10	0.17	0.25
Morrison	0.05	0.06	0.08
Mountain Water and Sanitation Dist	0.01	0.03	0.05
Nederland	0.07	0.11	0.13
Niwot	0.24	0.32	0.46
West Jefferson Co	0.08	0.35	0.52
Bennett	0.09	0.17	0.25
Byers	0.06	0.07	0.10
Deer Trail	0.04	0.04	0.04
Strasburg	0.10	0.15	0.30

(1)In addition, Broomfield has flows of 1.6 in 1975, 3.3 in 1985 and is phased out by 2000. Lower Thornton is assumed on-line by 1985.

(2)Assumes Golden on-line by 1985, Lower Thornton going to Big Dry Creek by 1985, and the total service area flow for Sand Creek with the exception of Aurora Westerly Creek being handled by the Sand Creek plant for 1985 and 2000. The values shown include Denver Northside flows.

Four stream classification alternatives were identified for the various stream reaches. Cost estimates were then developed and wasteloads allocated based upon the classification alternatives. These alternatives are presented in the Technical Report. Based upon costs of and benefits from achieving each water quality level, Figure II-2 shows the recommended classifications for the area's streams. The recommended classification system which directly translates into costs and treatment levels should be considered an interim goal. This goal is a combination of various water quality levels in the region which relate to desired and attainable water quality.

The classification process also evaluated the affect of nonpoint pollution on meeting the various potential classifications. Probability tables showed interesting results concerning the impact of nonpoint pollution. Essentially the highest stream alternative having primary contact as a beneficial use cannot be attained without major nonpoint source controls. The same is also true for the other stream classification alternatives only to a lesser extent.

The interim goal falls short of meeting the national goal of fishable/swimmable water by 1983. However, federal guidelines allow for deviations from meeting the 1983 goal if one of the following conditions exist: (1) Use cannot be attained because of natural background conditions, (2) use cannot be attained because of irretrievable man-induced conditions or, (3) use cannot be attained because the imposition of pollution controls would result in a substantial and widespread adverse economic and social impact. Each of these deviation conditions were considered for the streams shown by Figure II-2.

The attainment of the interim goal marks a logical and orderly progress toward the 1983 water quality goal. By instituting an interim goal, the present uses of the water resources in the area can be preserved, and the social and economic impacts can be mitigated by distributing costs of higher treatment over a longer period of time.

As required by state law, the Colorado Water Quality Control Commission has established a set of stream (water quality) classifications. Similarities and differences between the existing Commission classifications and those recommended in the Clean Water Plan are noted in Table II-4. The Commission is presently holding hearings on its proposed stream reclassification system, which is based on establishing certain beneficial uses in the various stream reaches. It is anticipated that the proposed system of use classification will be adopted.

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TABLE II-4. Comparison of Existing and Clean Water Plan Receiving Stream (Water Quality) Classifications.

Facility	Existing Classification	Clean Water Plan Classification
Englewood/Littleton	B_1	2,3,5,8
South Lakewood	B_2	2,3,5,8
MDSDD#1	B_2	2,3,8,A
Golden	B_2	1,2,3,5,6,7,8,B
Sand Creek	-	2,3,8,A
South Adams County	B_2	2,3,8,A
Brighton	B_2	2,3,8,A
Big Dry Creek	-	2,3,5,8
Boulder	A_2	1,2.3,5,6,7,8
Longmont	B_2	2,3,8
Erie	B_2	2,3,5,6,8
Lafayette	B_2	2,3,5,6,8
Louisville	B_2	2,3,5,6,8
Glendale	-	2,3,5,6,8
Lyons	B_2	2,3,5,6,7,8
Niwot	-	2,3,8
Mountains	A_1 or B_1	1,2,3,4,6,7,8
Plains	-	2,3,8

Existing -
- A1 - Cold water fishery and primary contact recreation.
- A2 - Warm water fishery and primary contact recreation.
- B1 - Cold water fishery and secondary contact recreation.
- B2 - Warm water fishery and secondary contact recreation.

Clean Water Plan -
1. Primary contact recreation
2. Secondary contact recreation
3. Agriculture
4. Cold water biota
5. Warm water biota
6. Water supply - groundwater
7. Water supply - surface water
8. Wildlife

A. Provided municipal raw water supplies are not degraded.
B. Provided a cold water biota could not be attained without a substantial increase in streamflow.

The effluent characteristics necessary to attain desired instream water qualities are listed in Table II-5 for each of the 28 treatment facilities. The effluent qualities are based on the equal treatment methodology which requires that all facilities discharging to the same stream reach treat effluent to the same level. Permissible effluent concentrations were determined from water quality modeling.

For the purposes of this plan, effluent quality has been determined related to five water contaminants: five-day biochemical oxygen demand (BOD_5), ammonia nitrogen (NH_3-N), phosphate-phosphorous (PO_4-P), free residual chlorine (Cl_2) and fecal coliforms. These contaminants were chosen from the many present in sewage effluent for the following reasons:

All five are commonly present in chlorinated secondary effluent.

All five can be routinely and precisely monitored.

Excessive concentrations of each contaminant will eliminate one or more of the stream classifications.

Routine and reliable treatment processes are available to reduce concentrations of all five contaminants to harmless levels.

Treatment processes for the removal of these five contaminants were selected on the basis of proven reliability and the availability of reasonably accurate capital and operation and maintenance costs. The following processes were used for the cost estimates:

Activated sludge process (capable of reducing BOD concentrations to either 30 or 20 mg/l).

Nitrification (capable of reducing NH_3-N concentrations below 3 mg/l).

Breakpoint chlorination (capable of essentially eliminating NH_3-N in the effluent).

Multi-media filtration (capable of reducing suspended solids concentrations to below 5 mg/l).

Selective ion exchange for nitrogen removal (capable of reducing total nitrogen concentrations below 2 mg/l and NH_3-N concentrations below 1 mg/l).

Mineral addition to secondary treatment processes followed by filtration (capable of reducing total phosphorous concentrations below 0.5 mg/l).

Two-stage lime treatment followed by filtration (capable of reducing total phosphorous concentrations below 0.3 mg/l).

Dechlorination (capable of reducing Cl_2 concentrations below 0.5 mg/l).

TABLE II-5. Recommended Effluent Quality.

FACILITY	1985 FLOW (mgd)	EFFLUENT REQUIREMENTS BOD5(1) (mg/l)	NH3-N(2) (mg/l)	PO4-P(3) (mg/l)	Cl2(4) (mg/l)	FEC. COLI.(5) (org/100 ml)	WATER QUALITY LIMITED STREAM YES	NO	CONSTITUENTS
Englewood/Littleton	23.4	20	1	-	0.02	1,000	X		NH3, Cl2
South Lakewood	2.2	20	1	-	0.02	1,000	X		NH3, Cl2
MDSDD #1	139.0	30	-	-	0.5	1,000		X	
Golden	3.3	20	1	0.3	0.02	200	X		NH3, PO4, Cl2
Sand Creek	13.5	30	-	-	0.5	1,000		X	
South Adams County	3.8	30	-	-	0.5	1,000		X	
Brighton	2.1	30	-	-	0.5	1,000		X	
Big Dry Creek	6.7	20	1	-	0.02	1,000	X		NH3, Cl2
Boulder	15.2	20	1	0.3	0.02	200	X		NH3, PO4, Cl2
Longmont	8.2	30	-	-	0.5	1,000		X	
Erie	0.4	20	1	-	0.02	1,000	X		NH3, Cl2
Lafayette	1.3	20	1	-	0.02	1,000	X		NH3, Cl2
Louisville	1.3	20	1	-	0.02	1,000	X		NH3, Cl2
Glendale	1.3	20	1	-	0.02	1,000	X		NH3, Cl2
Evergreen	0.64	20	9	0.5	0.02	200	X		NH3, PO4, Cl2
Genesee	0.15	20	9	0.5	0.02	200	X		NH3, PO4, Cl2
Kittredge	0.08	20	9	0.5	0.02	200	X		NH3, PO4, Cl2
Lake Eldora	0.01	30	-	-	0.5	1,000		X	
Lyons	0.17	30	-	-	0.5	1,000		X	
Morrison	0.06	20	9	0.5	0.02	200	X		NH3, PO4, Cl2
Mountain Water and Sanitation District	0.03	30	-	-	0.5	1,000		X	
Nederland	0.11	20	1	0.3	0.02	200	X		NH3, PO4, Cl2
Niwot	0.32	30	-	-	0.5	1,000		X	
West Jefferson	0.35	20	9	0.5	0.02	200	X		NH3, PO4, Cl2
Bennett	0.17	30	-	-	0.5	1,000		X	
Byers	0.07	30	-	-	0.5	1,000		X	
Deer Trail	0.04	30	-	-	0.5	1,000		X	
Strasburg	0.15	30	-	-	0.5	1,000		X	

(1) Effluent BOD5 values of 20 mg/l are required for those plants with AWT. (2) Ammonia-Nitrogen (3) Phosphate-Phosphorus. (4) Total residual chlorine. (5) Fecal Coliforms.

In addition to the processes listed above, land application alternatives for wastewater facilities were evaluated. The results of the analysis show that the costs between conventional treatment and land application to achieve the recommended stream classification are comparable. Although cost estimates are comparable, land application is a site specific alternative and should be further evaluated in each 201 Facility Plan because of the uncertainty of water rights, land costs, and treatment level requirements.

Order-of-magniture cost estimates utilizing regional data were made for the wastewater facilities. Costs of treatment to the agencies are capital and operation and maintenance costs for the treatment facilities and for major sewers, including interceptors and large force mains with pump stations. Operation and maintenance costs for the collection systems were also included, but the capital costs of new collection systems were assumed to be borne by developers. The cost estimates do not include the bonded indebtedness of the existing facilities.

Most agencies will have to renovate and expand secondary facilities in order to meet projected population growth and construct new advanced wastewater treatment (AWT) facilities to satisfy stricter instream water quality standards. MDSDD#1 is also planning large capital expenditures for solids reuse and off-site sludge disposal facilities, while Denver is planning a large capital expenditure for digester gas reuse and renovation of its existing treatment plant.

The Englewood/Littleton facility has been designed as a regional facility to serve the two cities. Treatment will take place at the present Englewood site. The Big Dry Creek facility has also been designed as a regional facility to serve Westminster, Broomfield and a portion of Thornton. The possibility of treating a portion of the wastewater from Thornton in the Big Dry Creek regional plant is also being considered in the Lower South Platte Facility Plan. The Lower South Platte Interceptor, pump station, and force main is planned to convey wastewater from the Thornton service area to the Big Dry Creek plant.

Facility costs have not been included for Golden because the Phase 1 Report and Phase 1 Report Supplement for the Clear Creek Facility Plan show that a treatment facility in the vicinity of Golden is not cost effective. However, Golden and Arvada have expressed an interest in maintaining treatment facilities at the west end of the Clear Creek Basin in order to reuse their nontributary water for urban irrigation. An allowance for localized facility planning has therefore been made.

Glendale and Morrison could be served by the MDSDD#1 through existing interceptors. However, Glendale is presently expanding its treatment plant and has expressed the desire to keep its plant in operation. Glendale would therefore have to provide additional treatment facilities to obtain the recommended effluent quality.

Morrison has expressed a desire to remain autonomous and continue operation of its treatment plant. The total costs for treatment of wastewater from Morrison indicate that treatment at the Metro Central Plant would be the most efficient approach, but the cost difference is not enough to make that decision at this level of planning. Therefore, the costs included for Morrison could apply to either connection with the MDSDD#1 or construction of AWT facilities and continued operation of its own treatment facility.

Most Colorado communities have paid only a small percentage of the total construction cost of wastewater treatment facilities over the past five years. Federal monies have been made available under the Federal Construction Grants Program for as much as 75% of the cost of facility planning, design, and construction. State monies have been made available through the Small Communities Wastewater Planning Program on a need basis for predesign, design, and construction of wastewater treatment and collection systems. State funds have averaged about $2.5 million per year for the past three to five years.

Federal funds from the Construction Grants Program are allocated to applicants in accordance with a federally approved priority point system. The present system, approved by the EPA, was adopted by the Colorado Water Quality Control Commission on June 17, 1975. Based on the existing (FY-1977) priority points and subsequent ranking, several communities have already been allocated a portion of the federal funds for wastewater pollution abatement. However, in order to predict which of the remaining communities should receive funds and in which order during the next five-year planning period, a priority list for the various communities in the DRCOG planning area has been computed for the 1978-1982 period based on the existing state priority point system. The results of this computation are shown in Table II-6. The priority points for each facility were calculated using the following information:

Population forecast allocations of the Denver Regional Council of Governments.

The average daily flow projections.

Estimated present effluent concentrations from all facilities of 18 mg/l NH_3-N, 8 mg/l PO_4, and 0.5 mg/l Cl_2.

The recommended effluent qualities.

The BOD_5 points awarded to each facility in FY-1976 were adjusted for the difference between the BOD_5 limitation in the discharge permit and the recommended BOD_5 concentrations.

Stream category factors based on the equivalent Water Quality Control Commission classification under the Clean Water Plan.

The reuse points were assigned on the following basis: 10 bonus points for potable reuse of the effluent, 7 for industrial, and 6 for urban irrigation.

The priority rankings computed for the 1978-1982 time period may be compared with the existing priority rankings for FY-1977 in Table II-6. In most cases, the major differences between the two sets of rankings are a result of the recommended changes in the stream classifications. Facilities on the Lower South Platte River and St. Vrain Creek base priority points under the Clean Water Plan classification system. The Denver area sewers drop in the priority rankings because of the expected correction

TABLE II-6. Rankings Under the Existing Colorado Federal Construction Grant Priority System.

Facility	1977	1978	1979	1980	1981	1982
Englewood/Littleton						
Plant	1	2	2	2	2	2
Sewers	-	1	1	1	1	1
South Lakewood	4	8	8	8	12	12
MDSDD#1						
Metro Plant	7	20	20	20	23	24
Denver Plant	-	21	21	21	24	25
Lower South Platte Interceptor	-	22	22	22	6	6
Clear Creek Interceptor	-	22	22	22	6	6
Sand Creek Interceptor	-	22	22	22	6	6
Denver Area Sewers	2	25	25	25	25	25
Golden	-	5	5	5	5	5
Sand Creek	3[1]	12	14	16	19	21
South Adams County						
Plant	10	30	30	30	30	32
Sewers	-	31	31	31	31	33
Brighton	12	34	34	34	34	34
Big Dry Creek						
Plant	9[2]	6	6	6	9	10
Sewers	-	7	7	7	10	11
Boulder						
Plant	6	3	3	3	3	3
Sewers	-	4	4	4	4	4
Longmont						
Plant	8	17	17	17	20	19
Sewers	-	18	18	18	21	20
Erie	20	33	33	33	33	31
Lafayette						
Plant	17	16	13	14	17	17
Sewers	-	15	12	13	16	16
Louisville	18	19	19	15	18	18
Glendale	5	11	11	11	14	14
Evergreen	11	9	9	9	11	9
Genesee	-	14	16	12	15	15
Kittredge	15	28	28	28	28	28
Lyons	19	32	32	32	32	29
Morrison	13	13	15	19	22	23
Mountain W/S	-	29	29	29	29	30
Nederland	16	26	26	26	26	22
Niwot	-	29	29	29	29	30
West Jefferson County	14	27	27	27	27	27
Bennett	-	10	10	10	13	13
Byers	21	35	36	36	37	37
Deer Trail	22	36	37	37	38	38
Strasburg	-	38	38	38	36	36

[1] For City of Aurora

[2] For Broomfield/Westminster

of sewer overflows in 1977, while the Metro interceptors rise in the rankings at the end of the 1977-1982 period because of predicted overflows. Based on the projected ranking for each of the communities, a capital improvement program for achieving the stream classification can be developed.

Displayed in Table II-7 is a Capital Improvements Program for water quality facilities in the Denver 208 planning area from 1977 to the year 2000. The table shows detailed facility scheduling by year for the years 1977 to 1982 and less detailed scheduling for 1983 through 2000. The figures in the table represent estimated dollar amounts for planning, design and construction of sewage treatment plants, interceptor sewers and collection systems.

The amounts in Table II-7 were obtained from cost estimates performed for the facilities planning portion of the Clean Water Program and from information provided by the agencies listed. All costs were estimated to a 1977 base and inflated at 8 percent per year for the years 1977 to 1982. Inflation rates were not projected after 1982.

The costs are planning estimates and are considered to be within -30% to +50% of the actual costs for a particular facility. Final construction costs will be developed from detailed 201 facility plans. In addition, changes in the technical portion of the Program such as stream classifications and treatment processes could result in significant changes in costs.

The cost estimates for each facility (Items 1 through 29) are for treatment plants and major interceptors only. Collection systems are shown in Item 30 for the entire area.

The Capital Improvements Program includes projects to be funded by state grants, by federal grants, by a combination of state and federal grants and by local funds. Federal funds through the facility planning program will probably be the greatest source of outside revenue for local communities to construct wastewater treatment facilities to satisfy stricter water quality standards and growth demands. The scheduling of facilities in the 208 planning area has been based on a funding limitation of $22 million per year during the 1978-1985 period, with the stipulation that the state has two years to obligate the funds from any one fiscal year. The $22 million amount assumed in this work was established after discussions with Region VIII EPA and the proposed restrictions of a maximum of 55% of the state's allocation for work in the metropolitan Denver area. As in the past, grants for the plant facilities are for 75% of the total cost for planning, design, and construction. For interceptors and major force mains, federal monies through the 201 program have traditionally been offered for 90% of the design flow. Therefore, federal grants for major sewers were estimated at 68% of the capital cost.

The Colorado Department of Health also indicated that an additional $15 million of federal public works monies will be made available to Colorado in 1977 through the Nunn-Talmedge Act. This act reapportions federal funds to those states that received less than their fair share during the initial years of the program. Of this total amount, 55% has been assumed to be

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available to the DRCOG region for planning, design, and construction of wastewater facilities. The funds are expected to be handled in the same way as the construction grant monies.

Scheduling of grants in 1977 was based on the existing FY-1977 priority list and on information from the Colorado Department of Health on what communities were expected to apply for funds during 1977. No 201 funds were appropriated by Congress in 1977. Therefore, grant monies available during this year included unallocated funds from FY-1976 and Nunn-Talmedge funds.

Only planning funds were allocated from the federal 201 program to the plains and smaller mountain communities. Most of these communities are low on the priority list and cannot receive funds when desired. Therefore, it is assumed that they will look for alternative funding sources, such as the State of Colorado Small Communities Wastewater Planning Program.

INDUSTRIAL DISCHARGERS

Currently over seventy industrial dischargers in the five-county area have NPDES Discharge Permits. Of these, twelve were identified as potentially having a significant impact on the water quality in the area. These twelve dischargers were identified by examining their current NPDES Discharge Permits, their self-monitoring reports, EPA's STORET data and some were also identified by modeling their discharge on the receiving stream. The twelve dischargers are Great Western Sugar Company--Longmont and Brighton plants, Public Service Company--Valmont, Cherokee, Zuni and Arapahoe power plants, Flatiron Premix Concrete Company, Continental Oil Company, Asamera Oil Company (formerly The Refinery Corporation), U. S. Atomic Energy Commission's Rocky Flats plant, Gates Rubber Company, Martin Marietta Corporation--Waterton plant, and Adolph Coors Company--Golden.

Five of these plants will not need a new NPDES Permit to meet the 1983 requirements of Best Available Technology (BAT) for industry. They are Adolph Coors Company, Flatiron Companies, Gates Rubber Company, Great Western Sugar--Longmont and Brighton, and the Rocky Flats plant.

Of the remaining seven, Asamera Oil and Martin Marietta are currently meeting the BAT requirements. Public Service Company may need to upgrade its discharge in terms of temperature and TDS to meet the BAT requirements applicable to their industry. This will probably cost Public Service Company approximately $1.25 million for the four power plants. No water quality problems on Sand Creek or the Burlington Ditch are anticipated if Continental Oil Company meets the 1983 BAT requirements for its industrial classification.

It appears that BAT requirements are adequate to meet the recommended stream classifications for the seventy industrial dischargers with the possible exception of the Adolph Coors Company. The Clear Creek reach from Golden to the mouth is classified as primary contact recreation, warm water fishery, and water supply (surface and ground). This classification requires a high level of phosphorus removal, ammonia removal, and a nitrate-nitrogen level of less than ten milligrams per liter. No problems are anticipated with ammonia and nitrate-nitrogen since current discharge levels are within the allowable limits. The phosphate-phosphorus level in the effluent will need to be reduced to approximately 0.2 to 0.3 milligrams per liter in order to achieve a level of 0.1 milligrams per liter for primary contact recreation.

The majority of industrial residual wastes for the area are currently handled by the City and County of Denver at its sanitary landfill operation at the Lowry Bombing Range. The amount of liquid waste hauled to the site is between 30,000 and 50,000 gallons per day. The liquid industrial wastes are handled separately at this site by using deep unlined pits, approximately 10 to 20 feet deep, 30 to 50 feet wide, and about 200 feet long. The pits are filled approximately half full with liquid waste, and then solid waste material such as refuse and garbage is pushed into the pit and compacted. Finally, trash is placed over the pit, and the pit is sealed with several layers of dirt.

According to a recent report published by the United States Geological Survey entitled Ground Water Quality Near a Sewage Sludge Recycling Site in a Landfill Near Denver, Colorado,

> It would require about 500 years for the degraded water to move 2.5 miles from the landfill to the nearest domestic well. During this movement, the degraded water would be diluted by recharge of nondegraded water from the alluvium and would be further diluted by mixing with nondegraded water with the upper parts of the bedrock formation. Unless the landfill becomes a long-term source of large quantities of leachate, containing high concentrations of degrading constituents, it is unlikely that the degradation would ever have a significant impact on the ground water qualities at Well SC 4-65-30AAB (the nearest domestic well).

Recommendations for handling residual industrial wastes are as follows:

1. Use of the present Lowry disposal site should be continued and closely monitored. The monitoring recommendations made by the USGS in their report should be followed. This would include monitoring of the disposal area's wells once a year and sampling of wells on the perimeter of the site every six months.

2. State and local officials should develop criteria for the disposal of hazardous wastes on landfill sites.

3. A spill prevention program should be developed to allow the county and municipalities to respond to an accident which could result in the discharge of hazardous materials to the area's water courses.

4. Modifications should be made at the present Lowry site to prevent accidental discharge of the wastes to the surface water courses from spills or unusual weather events.

5. Land use controls will be needed to minimize construction on the Lowry landfill site and to prevent the development of wells in the groundwater system on and adjacent to the site.

SECTION III

NONPOINT SOURCE POLLUTION

GENERAL

Nonpoint source pollution is mainly attributable to man's activities on the land which create contaminants that are eventually carried into the streams and water bodies of the region. In determining the level of water quality desired for the Denver region, the impact of nonpoint pollution has been taken into consideration. The Clean Water Program verifies that nonpoint source pollution is significant for most study area basins.

Nonpoint source loads are measured in terms of pounds of constituent buildup per day on land surfaces. This somewhat understates the actual amount of pollutant load entering a stream after a typical storm because runoff events do not occur daily. In fact, assuming a maximum buildup at 30 days, the amount of pollutant entering a receiving stream after a month without precipitation could be up to 30 times greater than the daily values. Use of daily nonpoint source loads, however, allows for an equitable comparison with point sources based upon load considerations although the actual impact on water quality is not necessarily of the same magnitude.

WATER QUALITY MODEL

In order to relate point and nonpoint pollution to stream quality, the Clean Water Program utilized a dynamic simulation water quality model. This model gave a good time profile of water quality in each of the basins. The model was used to evaluate various control measures and strategies for both point and nonpoint source pollution. By utilizing this model as a planning tool, a sensitivity analysis provided the results necessary to indicate the various levels of nonpoint source control needed to meet the stream classifications.

Additional data is needed to assure that the model and analysis are accurately representing the impact of nonpoint pollution on water quality. This additional data, which will relate not only to the source but to specific instream water quality impacts, is needed prior to the investment of major financial resources. However, as will be shown later in this section during the data collection process implementation of certain nonstructural controls can be initiated.

POINT AND NONPOINT SOURCE COMPARISON

An analysis of the impact of nonpoint source pollution on water quality has shown that nonpoint sources contribute significantly more pollutants than point sources (with the exception of ammonia and phosphate) in every basin except the lower South Platte. This is partly due to the fact that most of the wastewater generated in the Denver region is treated and discharged from the Englewood/Littleton and Metro Denver plants and many of the basins have no treatment plants. It is difficult to evaluate the relative impact of point versus nonpoint source pollution strictly from a load perspective because of the timing differences where point source pollution is occurring constantly and nonpoint pollution occurs sporadically. Pollution from nonpoint sources will result in violations of the water quality criteria required by the various stream classification alternatives only during runoff periods of the year. As previously mentioned, total load figures are not a correct interpretation of the nonpoint source impact upon water quality. If used in conjunction with percentage tables (Figures 10-18 to 10-21 in the Draft Technical Report), however, an indication of the impact is possible.

A comparison of the state's proposed criteria with those parameters for which data was available indicated that nutrients, total dissolved solids (TDS), and bacteria entering the stream were the most common nonpoint source problems. Phosphorous in levels 100 times higher than desired was not uncommon. TDS was high in some stream reaches but could be controlled through nonpoint source programs.

Bacteria, expressed as fecal coliform and fecal streptococci, are public health hazards. Although they are not disease-producing themselves, they serve as indicators that pathogens could be present. Levels in the metropolitan area streams are very high in comparison with the standards for primary and secondary contact recreation. Therefore, bacteria appear to be the most detrimental pollution constituent to the Clean Water Program and will entail the application of extensive control measures.

Commercial and industrial land uses contribute the largest loads of bacteria and phosphate (as well as all other pollutant constituents). Single family land uses are also heavy contributors; not because they have the heaviest buildup rates, but because this land use category is heavily represented in most basins. Although multifamily land uses are responsible for heavy loadings of bacteria and phosphate in local areas, they are not especially significant at the metropolitan level because they do not represent a significant portion of the area's development. Control of runoff from the undeveloped land use categories--parks and recreation, natural, pasture, dry land and irrigated agriculture--is not considered to be a serious problem.

NONPOINT SOURCE CONTROLS

Urban Areas

Programs for controlling nonpoint source pollution in the Denver metropolitan area should be essentially the same for each basin with remedial programs relating to existing development and preventive programs relating to developing areas. Remedial programs include rigorous and more efficient use of typical urban housekeeping practices such as street sweeping, sewer flushing, and catch basin maintenance. Preventive programs incorporate nonstructural and structural measures that control and/or manage runoff before it presents a problem. Actions such as onsite detention and retention of runoff and control of pollutants generated by construction activities are effective means of minimizing additional runoff problems at minimum cost.

The Urban Drainage and Flood Control Manual has been generally formally and informally adopted by agencies in the study area. Approximately thirteen smaller municipalities and one county have not implemented use of the manual. Many of the control concepts dealing with urban runoff such as retention and detention basins provide benefits in addition to water quantity considerations. It is recommended each agency in the area involved in the control of urban runoff utilize the manual in reviewing development plans and enforce conformance with site plans.

Developed Areas

A general nonstructural program for developed areas which would avoid capital costs and emphasize existing maintenance programs incorporates the following recommendations to be initiated by the governmental agencies in the area:

Catch Basin Maintenance. Catch basins retain sedimentation, allowing coarse solids to settle within the basin. However, if basins are not cleaned periodically, pollutants trapped during previous runoffs are resuspended and washed into the receiving stream. Cleaning of catch basins after a major storm, or at least once every 30 days, improves water quality and allows the basins to operate more efficiently. Such cleaning is particularly important in commercial and industrial areas.

Street Sweeping and Parking Lot Cleaning. To prevent urban runoff from street surface contaminants, street sweepers should be replaced with vacuum-type street cleaners. Although vacuum systems are more costly to purchase, they provide ancillary benefits such as adaptors for catch basin cleaning and ease of operation that defray the additional capital cost. An increase in frequency of street cleaning, accelerated cleaning in commercial and industrial areas, and cleaning alleys at least three times a week and parking lots once a week could significantly reduce the buildup of pollution on these land surfaces.

Improved Leaf Collection. Rotting leaves in alleys, gutters, and other impervious areas increases the BOD and bacteria levels in urban runoff. Removal of leaves can reduce the cost of catch basin maintenance and street sweeping.

Eliminate Street Salting; Minimize Sanding. Salt application increases TDS loads and introduces cyanide, an anticaking agent. Sand applications increase the cost of street sweeping and catch basin maintenance and increase sediment loads. Other pollutants such as phosphate, pesticides, and oil tend to adhere to street sediments and are carried to receiving watercourses. This type of control should only be considered if unnecessary or over-useis occurring and implementation does not result in a potential hazard.

Structural controls for collecting, storing, and treating urban runoff in developed areas is extremely costly. Although this is the only way to meet the water quality standards 100% of the time, benefits would result for only portions of the year. Because development of these facilities is costly and not justifiable without further data and documentation, their use should not be required at this time.

Developing Areas

Preventive measures in developing areas result in water quality improvement. Although water quality standards will not be met continuously, a general enhancement of the environment by implementation of the following controls is recommended.

Environmental Ordinance. The Denver metropolitan area has a noticeable void of ordinances that deal directly with enhancement of water quality. Although local government, in some instances, reviews development plans with a view toward benefits to water quality, the criteria is usually loose and open to interpretation. Each local government in the study area should adopt an ordinance which identifies specific performance criteria. Such an ordinance would not only benefit water quality but also other areas of the environment such as enhancement of vegetation and wildlife habitat.

Although the local ordinance must consider local conditions, the following general requirements should be adhered to as closely as possible:

Site Plan. A site plan must be submitted for each new development or construction. The site plan will include information dealing with grading, clearing, grubbing, vegetation preservation, and erosion and sedimentation control. A performance bond or letter of credit should be posted by the developer which would include provisions for enforcement and would be sufficient to insure the implementation of the site development plan with sediment and erosion control. In general, the philosophy in enforcing the plan would be that no greater sediment load occurs during and after the development than would have occurred during historic or natural conditions. This would be similar to the requirements for the planning of urban runoff quantity flows, as specified in the Urban Drainage Criteria Manual.

Performance Standards. The following performance standards should be required at the local level:

The smallest practical area of land shall be exposed at any one time during development.

When land is exposed, such exposure shall cover as short a period of time as is practicable.

Natural features such as trees, groves, natural terrain, and waterways shall be preserved wherever possible.

The boundaries and alignment of streams shall be preserved and shall conform substantially with their natural boundaries and alignment.

Temporary vegetation and/or mulching shall be used to protect critical areas exposed during development.

Permanent final vegetation and structures shall be installed as soon as practical during the development.

Wherever feasible, natural vegetation shall be retained and protected.

No topsoil shall be removed from any areas except those intended for structures or to be covered by manmade improvements. Any topsoil removed shall be redistributed within the boundaries of the land in question so as to provide a suitable base for seeding and planting.

The development shall conform to the topography and soils so as to create the least erosion potential.

Provisions shall be made to effectively accommodate increased runoff caused by changed soil and surface conditions both during and after development.

Sediment basins (debris basins, desilting basins or silt traps) shall be installed and maintained to remove sediment from runoff water from the land being developed.

In both urbanized and developing areas there are some general actions which can be used by planners and engineers to help reduce the nonpoint source pollution. Some of these generally applicable planning techniques and ordinances follow.

Grading Ordinance. Such ordinances describe the manner in which grading shall be done - i.e. with the contour of the land. They can be written to limit the percent of soil left unprotected at any time. Colorado's Uniform Building Code contains a general sample ordinance.

Erosion/Sedimentation Control. These help carry out the details of a site plan. They are generally short-term and oriented to specific development actions.

Littering Ordinance. By limiting the amount of litter through stringent cleanup practices and fining programs the total pollution load can be reduced and prevented from reaching the streams.

Zoning Ordinance. Various types of zoning activities can be effectively used to limit impact on the streams and waterways. Examples are incentive zoning and transfer of development rights where a developer could be awarded density bonuses for using water pollution control measures in his design. The advantage of implementing some additional water pollution controls through the normal zoning/planning processes is that there would be little increase in cost.

Subdivision Regulation. It is usually this ordinance which describes the steps required for development of sites. These could be amended to reflect the needs of water pollution controls.

Economic Incentives. Taxation and pricing measures such as various tax waivers could make the purchase or installation of cleaning, recycling or preventive equipment (vacuum street sweepers) economically attractive.

Other Means of Regulation. Licensing and inspection requirements could be increased pertaining to measures which contribute to water quality. The building code could be revised to reflect more latitude in construction requirements, such as permitting or requiring pervious paving materials.

Individual Waste Disposal Systems

The tendency toward dispersed growth means that individual wastewater treatment will continue to be used throughout the region. Septic tanks are the predominant method used. Other systems do not offer the advantages of operating simplicity and economy of properly constructed septic tanks with soil absorption systems. It is generally assumed that the life expectancy of a soil absorption system is between 10 and 20 years, which means that in the septic system approval process alternatives should be considered for future waterwater treatment.

County health departments regulate and oversee septic tank systems. There were approximately 26,000 septic systems in the 208 area in 1976. Identification and enforcement of strict regulations on existing systems is extremely difficult. However, the implementation of a permit system requiring an inspection of existing and new septic systems on a periodic basis would be beneficial. Inspection frequency would vary according to how critical or potentially hazardous the area supporting the system is.

Agriculture

Controls for agriculture-related nonpoint source pollution concentrate on best management practices. Soil conservation techniques will focus on reducing pollution at the source rather than collecting and treating pollutants. Regulatory agencies can assist in determining the optimum use of fertilizers for better management of plant nutrients. Pesticides will be controlled to insure that they reach only target areas and species during application, do not migrate from the site, and where possible, biodegradable products will be used. Irrigation will be scheduled to provide water required only for crop production and a minimum amount for salt leaching. This lessens the amount of leaching which in turn reduces TDS and nitrate loadings in area streams.

These controls deal only with preventive measures. No requirement will be placed upon the agricultural community to implement a structural program for collection and treatment of the runoff. The preventive measures can be easily implemented with the exception of the last item which may be of concern to the agricultural community. This item must be carefully evaluated on a site specific basis because of the potential impact on the stream and groundwater resources.

SECTION IV

INSTITUTIONAL SYSTEM

BACKGROUND

For the first time in the history of federal water quality legislation, PL 92-500 provided explicit directives for planning and subsequent implementation of the 208 plans. Designation of DRCOG to prepare the initial 208 Plan for Adams, Arapahoe, Boulder, Denver, and Jefferson counties was the first step in the institutional process leading to achievement of the 1983 goals.

When the initial 208 Plan is approved by the Governor, he will designate two types of agencies with specific charters related to plan implementation: (1) an areawide planning agency to continue the regional planning process and (2) management agencies for managing construction and operational aspects of the plan. The major change from past practices is the designation of "management agencies," which are to be selected on the basis of their capabilities in the area of water quality management.

This institutional relationship between areawide planning and implementation agencies is designed to provide the following benefits:

1. Section 208 planning ensures that the most cost effective *regional* water quality management system is developed. Since 208 planning considers impacts from both point source and nonpoint source pollution, local governments can control the effect of both sources upon their water systems.

2. Section 201 planning deals with construction, operation, and maintenance of facilities and places the responsibility for developing the most cost effective local wastewater management systems on local governments within the parameters of the 208 Plan.

3. Because of the mandatory areawide planning requirements of PL 92-500, a local government can be assured that similar activities in adjacent areas are compatible with its own, and that it will not be adversely impacted by activities in upstream areas.

The planning process of PL 92-500 consists of two basic elements: (1) areawide planning at the multijurisdictional level under Section 208 and (2) facility planning by individual agencies under Section 201. The 208 planning process takes a broad perspective related to facility needs, scheduling, treatment levels, and setting priorities for needed facilities. Management agencies decide on the need for and specific characteristics of wastewater treatment processes and the details of implementation within the parameters of the 208 Plan.

INSTITUTIONAL ARRANGEMENTS

The following five elements are essential aspects of the Clean Water Plan:

1. Management Agencies
2. Areawide Planning Agency
3. Nonpoint Sources
4. Regulatory Agencies
5. The 208 Planning Process

The interrelationships of these elements and close coordination of the agencies involved will determine the success of the Clean Water Plan.

Management Agencies

Thirty-four management agencies designated by the Governor to implement the 208 Plan will have the following authorities:

1. The authority to carry out the appropriate portions of the areawide wastewater treatment management plan developed under Section 208 of PL 92-500.

2. The authority to effectively manage wastewater treatment works and related facilities serving the 208 area in conformance with the 208 Plan.

3. The authority, directly or by contract, to design and construct new works and to operate and maintain new and existing works as required by the 208 Plan.

4. The authority to accept and utilize grants and funds from other sources for wastewater treatment management purposes. Management agencies, after designation, are the only agencies authorized to receive federal grants, though other agencies may receive grant funds through designated agencies.

5. The authority to raise revenues, including the assessment of wastewater treatment charges.

6. The authority to incur short- and long-term indebtedness.

7. The authority to assure, in implementation of the 208 wastewater treatment management plan, that each participating community pays its proportionate share of treatment costs.

8. The authority to refuse wastewater for treatment from any municipality or subdivision thereof which does not comply with any provision of the 208 Plan applicable to such area.

9. The authority to accept industrial wastewater for treatment.

Basins or service areas shown in Figure IV-1 will be the basis of assignment of implementation responsibility. All existing wastewater treatment agencies will be designated management agencies with the exception of Longmont and Lyons which will be encompassed within the St. Vrain-Left Hand Water Conservancy District. This will result in the designation of 34 management agencies. Collection and interceptor agencies will not be designated management agencies, but will rely upon the treatment agency to which they are tributary for coordination and access to state and federal grant funds.

A basin or service area approach is selected as the management concept because water quality management issues and problems can be addressed in a comprehensive manner by focusing on an entire basin or service area. Since water quality problems and solutions are intergovernmental in nature, an intergovernmental approach will be established among existing local governments and wastewater management agencies within a basin or area.

The basin or service area approach can effectively implement the technical program developed to meet PL 92-500 requirements. Management agencies under this system will be in a position to effect administrative cost savings associated with joint planning, engineering, legal, accounting, billing, purchasing, and other management activities for which each of the 154 agencies must provide under the existing system. While the decision on facilities planning will have a greater financial impact than the decision on the institutional approach to be taken, the potential administrative cost savings associated with the basin approach should not be overlooked.

Implementation of this approach requires only minor modifications, if any, to existing legislation and minor changes in agency relationships and procedures. Present planning and coordination requirements will be greatly simplified. Each management agency is to be responsible for plan implementation within its service area, including all tributary collection and interceptor facilities. Plan implementation will be conducted at the basin or area level by an association of the designated management agencies within that basin or area as shown in Figure IV-1. The 34 designated management agencies will form a committee to serve as an advisory body to DRCOG for 208 related matters. Table IV-1 lists management agencies to be designated by the Governor by basin or service area. DRCOG will be responsible for coordinating the activities of the management agency groups.

From the perspective of the wastewater treatment officials, orienting management programs along natural drainage systems or existing service areas is a logical and technically sound approach. From the perspective of local elected officials, the approach is potentially more efficient than the existing system and, therefore, costs citizens less while retaining local policy control.

PAGE NOT

AVAILABLE

DIGITALLY

TABLE IV-1. Proposed Designated Management Agencies.

Basin or Area	Management Agencies
Littleton/Englewood Service Area	Littleton Englewood
Metro Service Area	Aurora Arvada Denver Glendale Brighton South Lakewood Sanitation District Northwest Lakewood Sanitation District South Adams County Water and Sanitation District Crestview Water and Sanitation District Hi-Land Acres Water and Sanitation District Clear Creek Valley Water and Sanitation District Wheat Ridge Sanitation District Metropolitan Denver Sewage Disposal District Number One (MDSDD#1)
Big Dry Basin	Broomfield Westminster
Coal Creek Basin	Erie Water and Sanitation District Lafayette Louisville
Boulder Creek Basin	Boulder Nederland Lake Eldora Water and Sanitation District
St. Vrain Basin	St. Vrain-Left Hand Water Conservancy District
Jefferson County Mountain Area	Evergreen Sanitation District Genesee Water and Sanitation District Kittredge Water and Sanitation District Morrison Sanitation District Mountain Water and Sanitation District West Jefferson County Sanitation District
Plains Area	Deer Trail Bennett Sanitation District Byers Water and Sanitation District Strasburg Water and Sanitation District

Areawide Planning Agency

The Denver Regional Council of Governments will be designated by the Governor to serve as the areawide planning agency and will have the following responsibilities for the counties of Adams, Arapahoe, Boulder, Denver, and Jefferson:

1. Continuous 208 water quality planning consistent with related areawide environmental and land use planning efforts.

2. Providing guidance to management agencies in implementing the 208 Plan.

3. Annual 208 Plan updating, including population and land use forecasts, wasteload allocations, needed facilities, construction scheduling, and funding priorities.

4. Annual state certification of consistency with the basin water quality plans developed by the Colorado Water Quality Control Commission.

5. Monitoring and evaluation of the plan implementation activities and progress of designated management agencies.

6. Annual report on progress towards meeting the 1983 goals of PL 92-500.

For twenty years wastewater agencies in the five-county metropolitan Denver area have worked together to solve water quality problems. In the late 1950s activities were initiated which led to the formation of the Metropolitan Sewage Disposal District Number One (MDSDD#1). It began providing secondary treatment for primary treatment agencies in four counties in 1966.

In the late 1960s all wastewater treatment, interceptor, and collection agencies were inventoried to obtain, for the first time, a clear picture of facilities throughout the region. During the same period, the Urban Drainage and Flood Control District (UDFCD) was formed to control flood waters. In the early 1970s, the "3C Plan" was developed setting forth wastewater facility needs for a twenty-year period. The 3C Plan was approved in 1974 for use on an interim basis, pending completion of an areawide water quality plan meeting requirements of Section 208 of PL 92-500.

DRCOG has been a major participant in all of these activities. It was the lead agency in providing a forum for discussion regarding the formation of MDSDD and UDFCD. It conducted the facility inventory in 1968 and was designated by the state to prepare both the 3C and 208 areawide water quality plans.

Procedurally, since the late 1960s, DRCOG, as the federally designated A-95 Metropolitan Clearinghouse, has reviewed and commented on facility proposals involving federal funds. Since 1971 the agency has conducted site location reviews for all new or expanded facilities under an agreement with the State Department of Health. Comments are based on consistency with regional plans and whether or not the facility is designed, sized, and located in a manner that meets water quality needs and protects the environment. The emphasis of PL 92-500 is on water quality control over an entire stream reach as it is affected by the policies and plans of counties and municipalities throughout the region and adjacent areas.

Nonpoint Sources

Water pollution from nonpoint sources includes runoff from urban areas and agricultural, forestry, construction, and mining activities. PL 92-500 mandates establishing a process to control nonpoint pollution sources. During the two-year 208 study, however, it was found that the Denver area lacks the data and analytical base needed to determine specific sources of nonpoint pollution and the beneficial affects of various remedial actions. While it is generally agreed that nonpoint sources cause water pollution, perhaps to a greater extent than point sources, the lack of information in this area significantly affected the proposed institutional approach to controlling urban runoff.

Management agencies for control of these pollution sources will not be designated until completion of a one to three year program of data collection and analysis conducted by DRCOG in cooperation with local, regional, state, and federal agencies. This program will identify and define specific sources, remedial measures, costs and funding sources, action schedule, and identification of appropriate agencies to be responsible for implementation.

Corrective programs will be directed at developing remedial measures to alleviate pollution from existing sources. In some cases the authority to develop such programs (such as municipal street cleaning and snow removal) already exists. In other cases, such as controlling runoff from existing residential or commercial developments, the legal authority to require expenditure of funds for remedial runoff control projects such as catch basins is questionable.

Preventive programs will be initiated to minimize the impact of potential new sources of nonpoint source pollution. These measures will be in the form of local ordinances and regulations for controlling runoff and could be incorporated into the development review process. General purpose local governments possess the authority to develop such regulatory controls, but there is presently no state requirement that they do so.

Regulatory Agencies

The traditional clearly defined role of local health departments in the maintenance of safe water supplies will continue. The U.S. Environmental Protection Agency's role is spelled out in PL 92-500 and its implementing regulations.

The key agency is the Colorado Water Quality Control Commission, supported by the Water Quality Control Division of the State Health Department. The Commission is ultimately responsible for achieving federal water quality goals throughout the state and, as agent for the state, has the following responsibilities:

1. Adopting a comprehensive program for the prevention, control, and abatement of water pollution.

2. Adopting and enforcing rules necessary to prevent, control, or abate water pollution.
3. Adopting and promulgating water quality standards for the various waters of the state.
4. Adopting standards for the discharge of wastes in order to attain and maintain water quality standards.
5. Reviewing and approving the location of proposed sewage treatment facilities.
6. Administering the national pollution discharge permit (NPDES) system.
7. Conducting statewide basin and 208 planning.
8. Approval of applications for state and federal construction grants.

In carrying out these responsibilities the state is responding to the requiring of PL 92-500. Consequently, it will annually submit a Colorado Program Plan to the EPA. The Program Plan will report the progress the state is making in meeting the federally mandated water quality goals and objectives and will include a prioritized list of wastewater facilities to be funded during the coming year.

Although the state is responsible for statewide water quality planning and enforcement, it is expected that it will continue to delegate much responsibility to areawide agencies in accordance with programs developed as part of the 208 areawide planning processes. In the Denver metropolitan region, DRCOG will be the 208 continuing planning agency. As part of the continuing coordination process between the state and its regional planning agencies the state is expected to establish the following policies:

1. An annual production date for the Colorado 208 Program Plan.
2. A system for integrating project priority programs developed by 208 continuing planning agencies into a statewide project priority list in coordination with the 208 planning agencies.
3. A date by which all 208 areawide planning agencies must submit their annual 208 plan updates. It is expected that state consideration of updated plans will be minimal since they will usually include only a few changes within an established plan and presentation format.

The 208 Planning Process

Federal regulations require that a "continuing planning process" be established to meet requirements of PL 92-500. This process is envisioned as having several distinct responsibilities including conducting studies in support of ongoing 208 planning and local wastewater management facilities planning, reviewing plans and proposals from local management agencies, and annually submitting a revised 208 plan to the state describing regional water quality management activities that will be conducted during the coming year. It will also include any changes in facility needs or other planned actions in the ensuing five and twenty year periods.

EPA's State Continuing Planning Process Handbook presents the follow-guidelines which will be followed by DRCOG:

1. Planning should guide management.
2. The planning process should be intergovernmental and integrated.
3. Local officials must be involved.
4. Areawide planning must be integrated with state planning.
5. The planning process should be flexible.
6. Priorities must be set using the planning process.
7. Deadlines should be specified.
8. Timing sequences must be set.
   a. DRCOG will submit an annual update of its water quality control plan to the state for inclusion in the state 208 Plan.
   b. The annual updating process will include five-year capital improvement programs which list all structural means of abating point and nonpoint source pollution in order of priority.
   c. A twenty-year planning sequence will consider land use changes, changes in economic and demographic conditions, and resulting future impacts on wastewater treatment facilities. This will also be updated annually, with the five-year program included.
9. The continuing planning process must be broad in scope.
10. The continuing planning process should be coordinated with other water quality planning efforts and with complementary system planning.
11. The continuing planning process should build on existing plans and existing organizational arrangements.
12. Full public participation must be structured and encouraged.

The 208 annual plan updating process will involve the 34 management agencies, DRCOG, the state, and EPA in the relationships depicted in Figure IV-2. One representative of each management agency, three members of a water quality subcommittee of the DRCOG Citizens Advisory Committee, and three members of the Water Resources Advisory Committee will comprise a Water Quality Advisory Committee to DRCOG during preparation of the annually updated Clean Water Plan and in determining construction needs, scheduling, and priorities within the 208 Study Area.

Memorandum of Understanding

Each group of management agencies will function in accordance with a Memorandum of Understanding regarding the preparation of the following documents:

A summary of the Clean Water Plan implementation to date in the basin.

A report on the relationship of local facility plans to the Clean Water Plan.

Five Year Capital Improvement Program, including funding needs for the basin.

Priority list for funding facilities in the basin.

List of updated A-95 reviews for the following year.

Report on local ability to implement the Clean Water Plan, problems being encountered, and proposed changes.

Revisions to the Clean Water Plan for the basin.

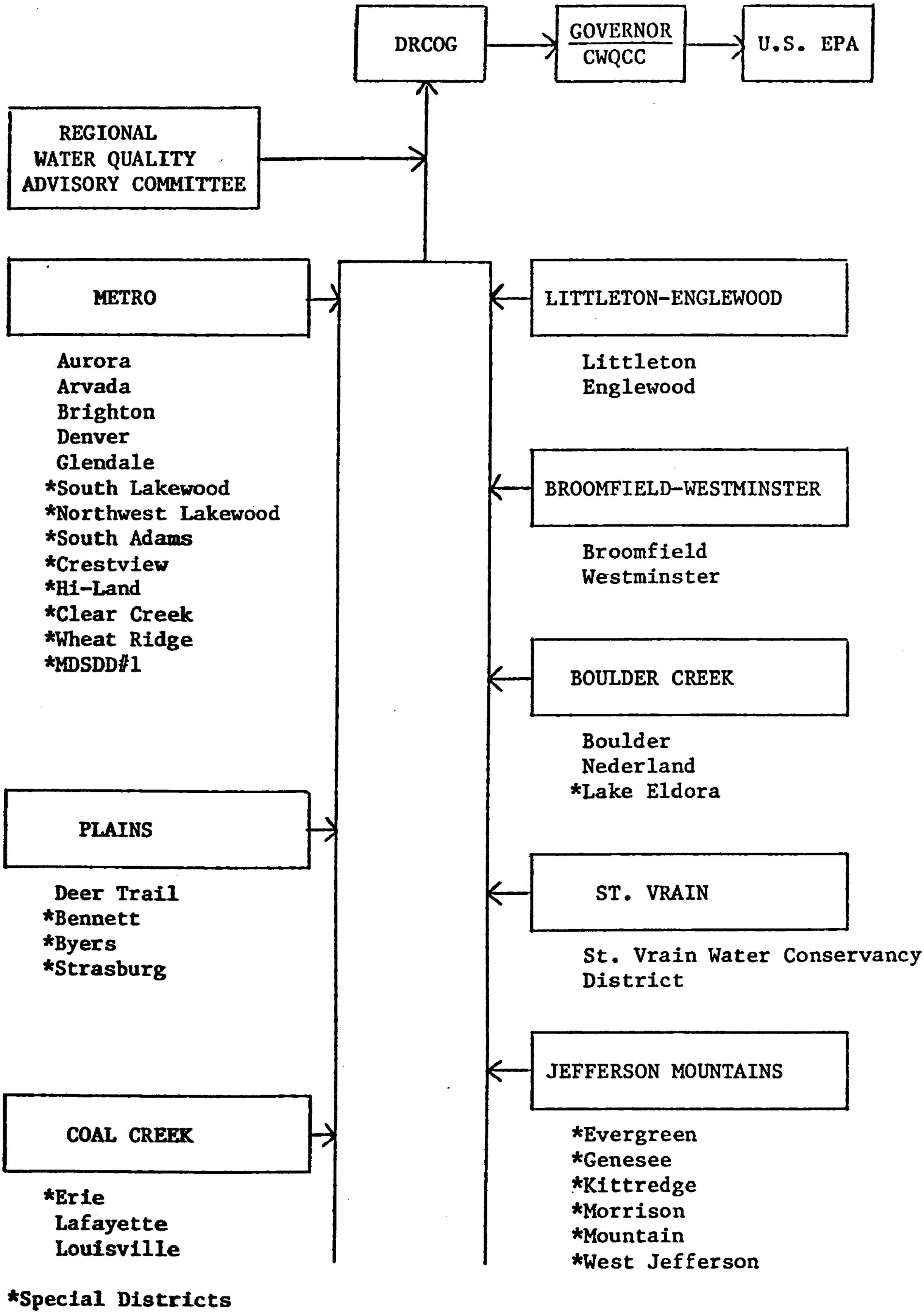


FIGURE IV-2. Clean Water Plan Approval and Update Process.

A Memorandum of Understanding will be developed between DRCOG and the management agency groups, covering the following elements:

Schedule for preparation of the annual Clean Water Plan update.
Interim (semi-annual) plan amendment process.
Preparation of facility needs and scheduling in 5 year increments up to 20 years.
Developing a priority listing for facility funding.
Providing information to DRCOG for clean water planning activities.
Information to be provided by DRCOG to management agencies.

At the end of two years, the effectiveness of the Memorandum of Understanding will be evaluated and one of the following courses of action taken:

Continuation of the Memorandum of Understanding.
Revision of the Memorandum of Understanding.
Designation of fewer management agencies in each basin or subarea and one of the above as appropriate.

At the end of five years after approval of the initial Clean Water Plan, designation of only one management agency in each basin or service area will be implemented if justified by appropriate analysis and local support. In the long term, if a form of metropolitan governance is established in the Denver metropolitan area, wastewater management consolidation into such an organization should be considered.

Project Review

The process will include annual submission of a project list by the management agency groups to DRCOG, as specified in the Memorandum of Understanding. DRCOG will review each project for which 208 planning priority is requested according to the following criteria:

1. Extent to which the project is consistent with the Clean Water Plan.

2. Extent to which the project duplicates, opposes, or needs to be coordinated with other projects.

3. Extent to which the project might be reviewed to increase its effectiveness or efficiency.

4. Extent to which the project contributes to the achievements of areawide objectives and priorities related to natural resources and economic and community development.

5. Extent to which the proposed project significantly affects the environment.

6. Extent to which the project contributes to more balanced settlement and delivery of services to all sectors of area population including minority groups.

If a project is accepted based on these criteria, it will be eligible for inclusion in the regional facility priority list prepared annually by DRCOG.

If after positive review and priority assignment a project is not funded in that year, it will automatically be included in the regional priority list the following year unless subsequent studies indicate that the project is no longer advisable. Project seniority will not necessarily have a bearing on year-to-year priority ranking, however.

DRCOG will review new or expanded project proposals only once a year in conjunction with the annual Clean Water Plan update process. The process will be coordinated with state procedures. A semi-annual plan amendment procedure will provide one other opportunity for plan changes, which, if approved, will be incorporated into the subsequent plan update. Changes in the plan at other times will be made only in exceptional circumstances.

Updated Clean Water Plan Approval

The first draft of the annually updated regional Clean Water Plan will be submitted to each management agency for its review. DRCOG may modify the plan to reflect management agency disagreements with regional project priority listings or other program plan elements. After discussion and appropriate revision, the annual Clean Water Plan will be officially adopted by DRCOG and submitted to the state for recertification. The state will then review the plan based on the following considerations:

1. Consistency with the basin or area plans developed by the Water Quality Control Commission.

2. Compatibility with 208 plans in areas adjacent to the Denver 208 planning area.

3. Progress towards meeting the federal and state 1983 water quality goals.

After recertification by the Governor, the updated plan will be submitted to the EPA for approval.

Other Considerations

The Clean Water Plan, when certified and approved, will govern decisions of state and federal agencies as to facility approval and grant funding.

Proposals for new, expanded, or replacement facilities will be reviewed and approved by DRCOG only twice a year: (1) during the annual Clean Water Plan updating process and (2) during an interim semi-annual plan amendments as they affect their respective basins or areas and approve such expansions or extensions only at those times.

A-95 and site location review and approval of projects will be accomplished as part of the annual Clean Water Plan updating or semi-annual plan amendment process. This approval and A-95 review will occur at the completion of the 201 Step 1 facilities planning and no further review will be necessary unless the project or circumstances change substantially.

Construction priorities will be set annually, consistent with state, basin or area, and areawide criteria as appropriate. Three priority lists will be prepared for each basin or area to be incorporated into similar areawide lists as follows: (1) facilities planning (201), (2) engineering and design, and (3) construction.

The annual Clean Water Plan updating process will be consistent with the annual state plan preparation and priority setting process.

Procedures and criteria for designating management agencies will be developed by DRCOG with the assistance of local agencies.

The state's technical criteria for determining funding priorities should remain the same from year to year with annual policy changes as appropriate.

Grant funds should be allocated to 208 planning areas with policy guidance as to use with a reserve retained by the state for contingencies.

APPENDIX D

TECHNICAL REPORT

SUMMARY

DRAFT

CLEAN WATER PROGRAM

Technical Report Summary
DRAFT
For Discussion Purposes Only

Clean Water Program

Denver Regional Council Of Governments

SUMMARY REPORT

DENVER REGIONAL COUNCIL OF GOVERNMENTS

CLEAN WATER PROGRAM

MARCH 1977

The preparation of this document was financed by an areawide water quality management planning grant from the U.S. Environmental Protection Agency.

This document has been prepared for the convenience of citizens and governmental officials involved in the 208 Clean Water Program. It summarizes the Technical Report Draft, dated March 1977. For more detailed information and documentation, contact DRCOG. Consultant reports will also be available for review and the staff will be on hand to answer your questions or discuss your concerns.

CONTENTS

CONTENTS (Continued)

CLEAN WATER PROGRAM

CONCLUSIONS AND RECOMMENDATIONS

(For discussion purposes only)

MANAGEMENT AGENCIES

Conclusions:

Independent activities of 150 wastewater agencies make coordination of decisions and operations extremely difficult within the 208 Study Area.

Treatment agencies provide a focal point for management of the treatment process and for decisions affecting scheduling and sizing of interceptors and collector systems.

The basin-oriented approach provides for local control of decisions, but recognizes the need for a multijurisdictional perspective.

Where intergovernmental agreements exist, they provide a good basis for management coordination. Where such agreements do not exist, coordinative mechanisms should be established.

The lack of data regarding nonpoint source water pollution makes it impractical to assign management responsibility in that area at this time.

Recommendations:

For the short term, basins and service areas should be the basis of revised institutional arrangements.

All district and municipal treatment agencies as of July 1, 1977, should be designated management agencies, except the cities of Longmont and Lyons and the Niwot Sanitation District which will be within the St. Vrain-Left Hand Conservancy District and the Highline Park Water and Sanitation District which will be represented by the Supervisory Group of Littleton/Englewood management agency.

One representative of each management agency, three members of a water subcommittee of the DRCOG Citizens Advisory Committee, and three members of the Water Resources Advisory Committee should comprise a Water Quality Advisory Committee to the designated 208 planning agency.

Management agencies should not be designated at this time for control of urban runoff or pollution resulting from agricultural, construction, forestry, and mining activities.

Proposed Designated Management Agencies.

Basin or Area	Management Agencies
Littleton/Englewood Service Area	Littleton Englewood
Metro Service Area	Aurora Arvada Denver Glendale Brighton South Lakewood Sanitation District Northwest Lakewood Sanitation District South Adams County Water and Sanitation District Crestview Water and Sanitation District Hi-Land Acres Water and Sanitation District Clear Creek Valley Water and Sanitation District Wheat Ridge Sanitation District Metropolitan Denver Sewage Disposal District Number One (MDSDD#1)
Big Dry Basin	Broomfield Westminster
Coal Creek Basin	Erie Water and Sanitation District Lafayette Louisville
Boulder Creek Basin	Boulder Nederland Lake Eldora Water and Sanitation District
St. Vrain Basin	St. Vrain-Left Hand Water Conservancy District
Jefferson County Mountain Area	Evergreen Sanitation District Genesee Water and Sanitation District Kittredge Water and Sanitation District Morrison Sanitation District Mountain Water and Sanitation District West Jefferson County Sanitation District
Plains Area	Deer Trail Bennett Sanitation District Byers Water and Sanitation District Strasburg Water and Sanitation District

A model "Memorandum of Understanding" for each management agency group within the 208 Study Area should be prepared by the designated 208 planning agency.

At the end of five years after approval of the initial 208 Plan, if justified by appropriate analysis and local support, only one management agency should be designated for each basin or service area.

A form of metropolitan governance should be established in the future with enforcement and veto powers including the responsibility of wastewater management if justified by appropriate analysis.

208 PLANNING AGENCY

Conclusions:

Wastewater planning and resultant decision making need to be coordinated on an areawide basis to achieve the 1983 water quality goals.

The 208 areawide wastewater treatment planning process and the A-95 Metropolitan Clearinghouse process should be vested in the same agency.

DRCOG has experience in developing and coordinating water supply, sewer, transportation, criminal justice, recreation, housing, land use, and other regional programs and plans.

DRCOG has the requisite legal basis and experience in 208 areawide planning.

DRCOG, on behalf of local governments, can accomplish effective 208 areawide wastewater treatment planning, and, by being involved in the process at the regional level, local governments can effectively implement the plan.

DRCOG, as an organization of elected officials, provides an alternative perspective to wastewater implementation processes operated independently of other governmental concerns.

Recommendations:

DRCOG should be designated the continuing 208 Areawide Planning Agency for Adams, Arapahoe, Boulder, Denver, and Jefferson counties.

A "Memorandum of Understanding" should be developed between DRCOG and each of the management agency groups regarding the process and procedures to be used in 208 areawide planning and plan implementation.

DRCOG should be responsible for updating the 208 Plan annually and obtaining recertification by the Governor each year.

DRCOG should undertake cooperative programs of data collection, analysis, and interpretation of nonpoint source pollution problems with local, regional, state, and federal agencies.

POINT SOURCES

Conclusions:

Point sources are the major pollutant generators during low flow periods.

Point sources are the key contributors of ammonia which is toxic to fish.

Even with countrol of point sources to the highest level, year-around attainment of water quality standards is not possible.

The attainment of 1983 goals through point source controls is not possible without expensive nonstructural and structural nonpoint source controls.

Implementation of major point source controls must be evaluated as to the actual benefits derived from changes in beneficial use of wastewater.

Recommendations:

Continuation of smaller treatment facilities should be encouraged because of the higher potential for wastewater reuse and stream flow augmentation.

Wastewater reuse (successive use) plans for treatment facilities should be encouraged for both water quality benefits and overall water management benefits.

The recommended stream classification system shown in the figure and table contained in these conclusions and recommendations should be the basis for discharge permits, and design and construction of municipal facilities during the next several years.

Facilities planning by management agencies should continue to consider treatment alternatives compatible with 1983 goals during low flow periods.

Facilities planning should consider systems capable of meeting the 1985 goal through low cost processes such as agricultural reuse.

NONPOINT SOURCES

Conclusions:

On a regional scale nonpoint source pollution is a problem.

Data is not available to identify specific nonpoint pollution sources or the impact of specific pollution control measures.

Substantially more pollutant loading occurs from non-point sources than point sources in every basin but the Lower South Platte based on an average annual loading.

Major water quality problems occur with respect to fecal coliform and phosphate (PO_4).

Problems occur sporadically and with different frequency each year.

Nonstructural controls could reduce pollutant loading by 30% to 40% but still not meet stream standards.

Structural facilities are costly, but stream standards will be met if adequate point source controls are implemented.

Recommendations:

A nonstructural control program for general water quality improvement should be implemented.

Structural controls should be eliminated from further consideration until the continuing planning process identifies site specific problems and control measures.

A monitoring program should be implemented to gather data necessary for site-specific problem identification and to estimate control measure effectiveness.

Recommended Plan for Municipal Wastewater Treatment Plants.

Facility	Alt. Level	Cost[1] (Millions)	Effluent Requirements (mg/l)			
			BOD	NH_3-N	NO_3-N[4]	PO_4-P
Littleton/Englewood	2	48.1	5	1	1	8
South Lakewood	2	6.8	5	1	1	8
MDSDD#1	4	97.1	20	18	-	8
South Adams County	4	7.5	20	18	-	8
Brighton	4	4.1	20	18	-	8
Glendale	2	1.8	5	1	1	8
Sand Creek	4	16.0	20	18	-	8
Golden	2	9.9	5	1	1	0.3
Big Dry Creek	3	15.3	5	0-3[2]	15	8
Louisville	2	4.2	5	1	1	8
Lafayette	2	6.9	5	1	1	8
Erie	2	2.6	5	1	1	8
Boulder	2	24.2	5	1	1	8
Longmont	4	6.2	20	18	-	8
Mountains	1	5.0	20	9/15[3]	-	8
Plains	4	1.3	20	15	-	8

[1]These present worth costs reflect capital for facilities and interceptors and operation and maintenance of the facilities, interceptors, and collection systems through the year 2000.

[2]Full-time nitrification with part-time breakpoint chlorination for total ammonia removal.

[3]Bear Creek requires nitrification to 9 mg/l of NH_3-N, but all other mountain and plains areas are 15 mg/l NH_3-N as given in the Mountain and Eastern Plains Water Quality Study.

[4]Dash indicates that nitrate will not be a problem unless discharges are excessive.

PAGE NOT

AVAILABLE

DIGITALLY

INTRODUCTION TO THE CLEAN WATER PROGRAM

The Denver area 208 Clean Water Program was developed in response to federal legislation entitled "Federal Water Pollution Control Act Amendments of 1972" (Public Law 92-500). This legislation mandated the achievement of two national goals: (1) that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water be achieved by July 1, 1983," and (2) "that the discharge of pollutants into navigable waters be eliminated by 1985." In July 1974, the Governor designated the Denver Regional Council of Governments the "Areawide Waste Treatment Management Planning Agency" for the five county Denver metropolitan area. The DRCOG 208 Clean Water Program evaluates the national goals and their attainability in the Denver area with respect to financial, environmental, social, and economic impacts.

The U.S. Environmental Protection Agency is charged with the implementation of the federal program. In turn, the EPA has requested that the Governor's Office assume the responsibility of certifying areawide 208 plans throughout the state. Upon approval by the Governor, the plans will be forwarded to the EPA which is the major funding source for water quality management programs. In fact, the Clean Water Program has been funded by the EPA in the amount of $1.25 million.

The 208 Plan which will be submitted to the Governor's Office for certification will be the result of cooperative efforts involving citizens' groups; wastewater treatment management personnel; professional consultants; federal, state, and local governmental agencies; and the Water Quality Management Task Force. The Task Force, comprised of citizens with varied interests and points of view, was formed by DRCOG to oversee the progress of the program, select consultants, and review and approve major plan recommendations. Plan alternatives are now under consideration by all of these agencies and groups as presented in the DRCOG Clean Water Program Technical Report Draft of March 1977.

WATER RESOURCE SYSTEM

In addition to the federal water quality goals, the primary objectives for the Denver area Clean Water Program are (1) to determine technical solutions to regional pollution problems and (2) to establish a management system for implementing a plan to maintain clean water for various uses. The plan must consider the most economical and realistic methods to assure that water quality of every stream within the study area meets state standards established by the Water Quality Control Commission. To make this determination the study area was divided into subregions according to stream basins and wastewater treatment service areas. Water quality was monitored in all stream reaches (segments of similar character) and an analysis prepared of water quality impacts in each reach.

From the southern part of the Denver metropolitan area to the northern counties, study area subregions are briefly described as follows:

South Platte River Basins: Upper South Platte (284 sq. mi.) from Jefferson County line to the Town of Kassler.

South Metro (163 sq. mi.) from Kassler to Englewood, including Chatfield and Littleton.

Lakewood (36 sq. mi.) including the City of Lakewood and Edgewater.

Lower South Platte (97 sq. mi.) northeast of metropolitan Denver including the City of Brighton.

Bear Creek Basin (260 sq. mi.) from the mountains west of Evergreen to the South Platte River in Englewood, including Evergreen, Morrison, and small mountain communities.

Cherry Creek Basin (409 sq. mi.) from El Paso County to its confluence with the South Platte River near Larimer and Speer Blvd., including the cities of Denver and Glendale.

Sand Creek Basin (183 sq. mi.) from the plains southeast of Denver to the confluence of Sand Creek and the South Platte in metropolitan Denver, including Commerce City and the City of Aurora.

Clear Creek Basin (575 sq. mi.) from the mountains in Clear Creek County to the confluence of Clear Creek and the South Platte near Adams City, including Golden and Arvada.

Big Dry Creek Basin (111 sq. mi.) from Rocky Flats area to the South Platte north of Ft. Lupton, including Standley Lake, Broomfield, Westminster, and Northglenn.

Coal Creek Basin (65 sq. mi.) from the mountains northwest of Arvada to the confluence of Coal Creek and Boulder Creek just north of Erie, including Superior, Louisville, and Lafayette.

Boulder Creek Basin (366 sq. mi.) from the mountains west of Nederland to the confluence of Boulder Creek and the St. Vrain downstream of Longmont, including South Boulder Creek drainage area from west of Eldorado Springs.

St. Vrain Creek Basin (976 sq. mi.) from the mountains west of Lyons to the confluence of the St. Vrain with the South Platte near Platteville, including the cities of Longmont, Lyons, and Niwot.

The water resource system includes taking raw water from streams, lakes, and reservoirs; treating it for human consumption; distributing it to the water user; collecting and treating the returned wastewater; and discharging it into area streams, lakes, and reservoirs. In addition to the surface water sources, the Denver metropolitan area utilizes groundwater from wells and transmountain diversion water from the western slope. Groundwater quality is affected by surface water seepage and is a consideration of the Clean Water Program. Transmountain water added to local water courses receives the same treatment as local supplies. The addition of transmountain water to local streams has increased stream flow in some areas, thus improving acquatic habitat. Municipal and industrial wastewater discharges and agricultural return flows have increased stream flow in areas of historic low flow such as in Sand Creek and the Lower South Platte. These discharges have also degraded water quality in area streams.

Water Quality Planning Issues

The basin analysis indicated that the major water quality planning issues revolve around controlling both point and nonpoint source pollution and establishing an effective management system to assure that federal and state water quality goals are met. Point sources are municipal and industrial wastewater treatment facilities. Nonpoint sources are pollutant generators resulting from human activity on land surfaces such as urban runoff; agricultural uses of herbicides and pesticides; and construction, mining, and forestry activities resulting in stream degradation. The Technical Report details specific water quality issues for each basin.

Point sources can be regulated to maintain discharges within acceptable limits through plant improvements and utilization of new technologies. Control of nonpoint source pollution is much more difficult since it occurs over a wide area. If nonpoint source pollution overrides point source treatment solutions and continues to degrade the streams below federal and state water quality standards, major investments in plant improvements may not be practical.

Various methods of point source controls are considered in the Technical Report along with suggestions for nonpoint source pollution control. Implementation of these controls depends upon the water quality management system utilized to enforce treatment levels and monitor nonpoint sources.

INSTITUTIONAL ALTERNATIVES

At present more than 150 wastewater management agencies are functioning within the 208 Study Area. Implementation of the Clean Water Program is dependent upon the cooperation of these agencies and federal and state regulatory agencies. With increased federal involvement in establishing environmental standards and funding programs for local governments to meet federal and state requirements, it is necessary to develop a coordinative structure to collect data, prepare documentation, and anticipate regional impacts from the many plans and programs already underway. This involves two types of administrative responsibility: planning and management.

The Governor is responsible for designation 208 planning agencies for areawide planning in Colorado. He is also responsible for designating one or more management agencies within each planning area. The major stipulation for areawide planning agency designation is that the planning *board* be comprised of "elected officials from local governments or their designees." PL 92-500 designates certain authorities that management agencies must have to qualify for federal funding.

The 208 Planning Process

Federal regulations require that areawide water quality management include a "continuing planning process" to meet the requirements of PL 92-500. The continuing planning process envisioned by the EPA is a dynamic process involving participation at all governmental levels by citizens within the study area. In clarifying the 208 planning process it is necessary to define agency relationships, procedures for reconciling disputes, and processes for reaching decisions about water quality issues. This can only be accomplished through close interagency cooperation and citizen input.

The following principles are suggested by the EPA for a continuing planning process:

1. Planning should guide management.
2. The planning process should be intergovernmental and integrated.
3. Local officials must be involved.
4. Areawide planning must be integrated with state planning.
5. The planning process should be flexible.
6. Priorities must be set using the planning process.
7. Deadlines should be specified.
8. Timing sequences must be set.
   a. The 208 planning agency will submit an annual update of its water quality control plan to the state for inclusion in the state 208 Plan.
   b. The annual updating process will include five-year capital improvement programs which list all structural means of abating point and nonpoint source pollution in order of priority.
   c. A twenty-year planning sequence will consider land use changes, changes in economic and demographic conditions, and resulting future impacts on wastewater treatment facilities. This will also be updated annually.
9. The continuing planning process must be broad in scope.
10. The continuing planning process should be coordinated with other water quality planning efforts and with complementary system planning.
11. The continuing planning process should build on existing plans and existing organizational arrangements.
12. Full public participation must be structured and encouraged.

Levels of Planning

The Clean Water Program deals with three levels of planning: policy, program, and project. Water quality planning policies are set at several different levels of government. At the federal level the EPA has shifted from its traditional emphasis on facility planning to stressing nonstructural remedies to pollution and preventive rather than remedial actions. By explicit policy, the EPA has also transferred most decision making related to facility construction and improvement to the state.

The Water Quality Control Commission sets policies through its permitting and monitoring programs. By setting priorities for facilities and by enforcing or not enforcing state regulations the Commission will affect local water pollution control programs. On the regional level DRCOG has been responsible for policy making related to wastewater treatment in the five county area for almost twenty years. Whether DRCOG continues as the 208 Planning Agency or whether another regional agency receives that designation, the functions of reconciling areawide needs and providing a forum for setting regional policies for water quality management will have to continue.

Program planning involves the determination of what is to be accomplished to remedy specific water pollution problems. Like policy planning, program planning will be done at different levels of government. The EPA is responsible for major pollution control progams in accordance with PL 92-500. However, the Corps of Engineers, Bureau of Land Management, U.S. Department of Agriculture, and other federal agencies are involved in continuing planning processes as well.

At the state level, point sources are handled by the Water Quality Control Commission which administers most water quality related activities. Non-point pollution regulatory programs are dispersed throughout several state agencies. The Colorado 208 Planning Coordination Council, established by the Governor specifically to oversee areawide 208 planning, has the responsibility of coordinating all 208 planning activities of state agencies.

Areawide water quality program planning will be done primarly through the 208 program, but must relate to other planning efforts affecting water quality such as land use planning, growth management, transportation, etc. Human service programs including social services, manpower, and physical and mental health must be coordinated with the Clean Water Program continuing planning process.

Project planning is primarily a local governmental function accomplished under Section 201 of PL 92-500. The primary consideration of the areawide planning agency relative to project planning will be the reconciliation of conflicting demands for facility construction. Regional priorities among facilities must be set and recommended to the state. Because many new facilities will be required to meet the 1983 goals in the Denver metropolitan area, priority setting has already been initiated through the 208 planning process.

208 Planning Agency Designation

Five alternatives have been considered as planning agency possibilities in the metropolitan Denver area:

1. A state agency.
2. Counties.
3. All wastewater management agencies.
4. Basin or service area agencies.
5. A regional operating agency.
6. The Denver Regional Council of Governments.

The requirements of PL 92-500 appear broad enough to encompass most of these alternatives.

A state agency. The Colorado Water Quality Control Division has the responsibility for ensuring that 208 planning is accomplished statewide and is actually preparing plans for areas lacking 208 planning agencies. The state could also assume the responsibility for preparing the Denver area 208 Plan. In spite of its role in working with existing agencies, the state lacks experience in developing coordinative approaches to planning where participation of agencies areawide is required. It has traditionally deferred to regional councils of government such as DRCOG for this type of coordination.

Counties. Each of Colorado's 63 counties could be designated 208 planning agencies. Boulder County has asked DRCOG to investigate this 208 planning designation option as well as designation of Boulder County as a management agency. One reservation is that the resulting fragmentation of wastewater planning programs according to political rather than natural boundaries will not lend itself to effective coordination of planning activities beneficial to all jurisdictions sharing common water resources.

All Wastewater Agencies. Each of the 150 wastewater management agencies could be designated a 208 planning agency if it met the necessary requirements of PL 92-500. However, the same fragmentation and lack of "areawide" interest would result as discussed under the county designation. An additional coordinative structure would have to be established to respond to the regional planning requirements of the legislation.

Basin or Service Area Agencies. A basin-oriented agency which could coordinate wastewater management activities throughout the basin would be a logical choice for designation as a 208 areawide planning agency. However, the broad range of regional impacts would not be involved in this approach, although other planning concerns affecting water quality in the basin would be addressed by the 208 planning agency.

A Regional Operating Agency. A regional service authority, a metropolitan council, or a single-purpose regional wastewater agency could be designated the 208 planning agency. A regional service authority or metropolitan council could consider all aspects of area planning activity related to water quality control. A single-purpose agency would be limited to consideration of water quality planning and another coordinative process would be required to tie its activities to the efforts of other regional planning agencies. The advantage of this approach is that is separates planning responsibilities from the day-to-day activities of management agencies and offers a broader perspective of regional concerns.

The Denver Regional Council of Governments. DRCOG is governed by a board of elected officials with a broad, multifunctional perspective that interrelates planning activities and their effects within the Denver metropolitan area. With a twenty-year history of areawide water quality planning and designation as the 208 areawide waste management agency, it is in a good position to provide continuing planning services to the study area. DRCOG has had the experience of coordinating interjurisdictonal activities in mutually beneficial ways with locally elected officials meeting together to decide priorities and funding for facilities needed at the local level.

Management Agencies

Although PL 92-500 addresses areawide planning, the planning and management processes it encourages also pertain to subregional planning and management. One of the major benefits to local goverments from participating in the 208 program is that future federal construction grants will be contingent upon the existence of and compliance with an adopted 208 plan. The implementation of a cost effective regional water quality management system will benefit citizens on both local and regional levels. To accomplish this goal it is necessary that designated management agencies comply with the management requirements of PL 92-500 and with the provisions of the areawide 208 Plan. The following local planning benefits accrue from such compliance:

1. Section 208 planning ensures that the most cost effective regional water quality management system is developed. Since 208 planning considers impacts from both point source and nonpoint source pollution, local governments can be cognizant of the effect of both sources upon their water systems.

2. Section 201 planning, which deals with construction, operation, and maintenance of facilities, places the responsibility on local agencies to develop the most cost effective systems for wastewater management control within the parameters of the 208 Plan.

3. Because of the mandatory areawide planning requirements of PL 92-500, a local government can be assured that similar activities in adjacent areas are compatible with its own and that it will not be adversely impacted by activities in upstream areas.

The following agency authorities are required for designation as a 208 management agency:

1. The authority to carry out the appropriate portions of the areawide wastewater treatment management plan.

2. The authority to effectively manage wastewater treatment works and related facilities in conformance with the 208 Plan.

3. The authority, directly or by contract, to design and construct new works and to operate and maintain new and existing works as required by the 208 Plan.

4. The authority to accept and utilize grants and other funds for wastewater management purposes.

5. The authority to raise revenues, including the assessment of wastewater treatment charges.

6. The authority to incur short- and long-term indebtedness.

7. The authority to assure that each participating community pays its proportionate share of treatment costs.

8. The authority to refuse wastewater for treatment from any municipality or subdivision thereof which does not comply with 208 Plan provisions.

9. The authority to accept industrial wastewater for treatment.

Management Approaches

Six alternatives were considered for establishing the water quality management system in the 208 Study Area:

1. Continuation of the existing system.
2. Basin or service area approach.
3. Regional service authority.
4. Metropolitan council.
5. State-oriented approach.
6. Single-purpose agency approach.

Basically due to the lack of statutory authority, the metropolitan council, state-oriented, and single-purpose agency approaches were eliminated from final consideration. The Water Quality Management Task Force decided that the immediate implementation of a regional service authority would face serious impediments because of citizen opposition, apathy, and general timing uncertainty. Therefore, a short-term approach and a long-range objective were recommended by the Task Force. The short-term approach is the basin or service area alternative. The long-term objective is an undefined "form of metropolitan governance with veto power," perhaps similar to a regional service authority.

Many local officials expressed a preference for a network of subregional management agencies. The basin or service area approach appears to be acceptable since it can be accomplished in a way that allows local control to be maintained and guarantees local policy input. This approach also allows water quality management issues to be addressed in a comprehensive manner throughout the entire basin or service area. Since most water quality problems and solutions are intergovernmental in nature, the management agency under this system would be in a position to effect administrative cost savings associated with joint planning, engineering, legal, accounting, billing, purchasing, and other administrative activities for which each wastewater treatment agency is responsible under the existing system.

Implementation of the basin or service area approach would require only minor modifications to existing legislation and minor changes in agency relationships and procedures. Planning and coordination requirements would be greatly simplified. Each management agency would be responsible for coordinating the wastewater treatment activities within its jurisdiction. Representatives from each of the treatment facilities would participate on an advisory committee to the management agency to assure local input. A representative of the management agency would serve on an advisory committee to the regional planning agency.

The long-term objective of metropolitan governance will probably emerge during the process of implementing the 208 continuing planning process when interagency relationships are better defined and actual needs of the planning program to accomplish the 1983 goals are determined.

County Designation as Planning and Management Agency

As previously mentioned, Boulder County through its Consortium of Cities asked DRCOG to assess the feasibility of county designation as both planning and management agency under the 208 program. Based upon the following considerations, it appears that such a designation would not be in the best interest of continuing areawide planning processes required by PL 92-500.

1. Legal eligibility. It is not clear that Boulder County could be legally designated an areawide planning agency because it does not meet the requirement that the areawide agency be comprised of "elected officials from local governments or their designees." The final decision, however, rests with the Governor.

2. Technical plan implementability. The technical aspects of the 208 Plan could be effectively implemented by designation of Boulder County as a management agency. Designation of the county as an areawide planning agency, however, will not necessarily facilitate plan implementation or achievement of water quality standards.

3. Authority related to plan implementation. Planning agency designation may improve the county's ability to implement the 208 Plan within its jurisdictions, but areawide planning authority is not essential to plan implementation.

4. Land use control. Planning agency designation may increase land use control at the county level, but actual control may diminish as successful challenges to the application of water quality controls to land use and growth management are brought to the courts.

5. Local government acceptability. Boulder County municipalities are assured sufficient input into the continuing planning process regardless of which agency is designated the 208 planning agency. However, efficiency and coordination objectives would be more easily achieved if only one planning agency served Boulder County and its neighbors.

6. Ease of plan administration. The 208 Plan will be more difficult to administer if more than one planning agency is designated for an area with similar interests.

7. Cooperation with state agencies. Coordination of Department of Health, Water Quality Control Commission, and other 208 Study Area agencies involved in water quality planning will become more complex with two areawide planning agencies operating within the Denver metropolitan area.

8. Interfunctional coordination. Less effective consideration of impacts of other functional systems on water quality within the region may result from county designation as a planning agency.

9. Regional coordination. Coordination of planning and service delivery agencies areawide may require additional mechanisms if the county receives a separate planning agency designation.

Management of Nonpoint Source Pollution Controls

PL 92-500 mandates the establishment of nonpoint pollution source controls. However, the data and analytical base necessary for determining the sources of nonpoint pollution and the benefits of remedial actions are lacking for the study area. Research and monitoring activities of the 208 continuing planning process will generate more information for future analysis and decision making. Meanwhile, it is suggested that the Urban Drainage and Flood Control District which is already responsible for flood and urban runoff quantity control could become involved with water quality control as well.

POPULATION AND LAND USE IMPACTS

The rate and type of growth experienced by a region can significantly impact the quality of the area's water resources; however, only in recent years have attempts been made to quantify that impact. The Clean Water Program attempts to define development impacts on water quality and proposes measures to mitigate negative impacts. In order to accomplish this, historical development data and population forecasts have been developed for the Denver area. Land use criteria have been suggested for control of water pollution resulting from land use activities, especially urbanization.

During the past two decades the study area has experienced a growth rate double that of the national average. If the growth rate of the early 1970s were to continue, the Denver metropolitan region population would exceed three million in the year 2000. Since 1973 regional development planning has been guided by a set of policies adopted by DRCOG which established desired levels and locations for future growth and provided guidelines for more detailed planning. These policies include the following:

1. A population level below 2,350,000 should be encouraged for the Denver Metropolitan Statistical Area by the year 2000.

2. The central business district of Denver will be encouraged as the major high density core of business, cultural, governmental, commercial, and residential activity. Major high density corridors to the east, west, and south of the central business district shall be encouraged.

3. Several major activity centers shall be encouraged in the metropolitan area.

4. Low density residential growth should be encouraged only in locations contiguous to existing urban areas while considering local environmental or social concerns affecting the location of specific development.

5. New industrial development should be encouraged only in areas where environmental hazards can be effectively controlled or minimized.

6. Major unique urban areas will be encouraged to remain unique and not allowed to expand into nondescript, low density urban sprawl.

7. Major areas of environmental, agricultural, historic, and archaeological significance shall remain in natural open or low density urban condition.

8. The Regional Housing Plan directed at the provision of a decent home for every family, and in particular low and moderate income groups, shall be an integral component of all land use planning, particularly in relation to transportation, employment opportunities, and social services.

These policies were reevaluated in 1975-76 to determine the viability of the 2,350,000 population forecast. They were determined to be still valid.

In addition to the DRCOG forecast, two other relevant forecasts were considered: (1) the Colorado Division of Planning forecast recommended for use by the Colorado Water Quality Control Commission and (2) the U.S. Office of Business and Economic Research Service (OBERS) forecast which is used by federal agencies, including the EPA. The Colorado Division of Planning forecast projects a range of 1,612,189 to 2,417,275 for the year 2000. OBERS forecast, based on an allocation of national population projections, is 1,980,000 in the year 2000. However, based on recent growth trends, Colorado will probably continue to receive a larger percentage of migration than projected by the national forecast.

Population Projections and Wasteload Allocations

Increasing population means increasing amounts of discharges from wastewater treatment plants. The population data used in the Clean Water Program analysis was derived in three steps: (1) a reliable set of current population data was developed to determine per capita flows and calibrate sampling data; (2) two alternative population projections were provided to test initial water quality management alternatives; and (3) a final set of population forecasts was prepared for use in the analysis and preparation of the 208 Plan. The table on page 13 presents the alternative population projections for each basin of the study area. To allocate regional population forecasts to the basins, a computer model was employed. This model, knows as the EMPIRIC Activity Allocation Model, distributes a wide range of activities, including households, population, and employment, by numerous subcategories to the basin areas. The model requires a set of planning policy inputs to determine the impact of alternative policy decisions on regional growth.

Study Area Land Use Plans

The EMPIRIC model was also used to allocate land use to basin areas using the regional land use plan as the information base. Since no local data set comparable to the EMPIRIC model allocations was available, DRCOG developed a set of local land use plan data for comparison with the computer allocations. Adjustments in land use allocations based on developable versus overdeveloped areas were made. Local plans indicate more open space or undeveloped areas than are presented in the regional plan.

Reallocation of Adopted Regional Subarea Population Allocations To Basins, 1975-2000.

Basin	Current 1975	1980	Short Term 1985	1990	Long Term 2000
St. Vrain	43,240	58,930	59,430	68,300	87,300
Boulder Creek	99,830	107,940	117,730	127,780	144,290
Coal Creek	15,990	23,620	29,980	36,860	41,400
Big Dry Creek	28,750	43,230	55,100	68,270	98,060
Lower South Platte	21,010	45,635	54,860	65,090	103,570
Clear Creek	305,840	336,900	354,740	378,560	417,650
Sand Creek	169,640	186,120	211,264	234,659	306,600
Cherry Creek	342,310	364,950	386,060	408,710	485,820
Lakewood	266,290	263,800	265,190	265,950	273,820
Bear Creek	57,240	76,080	97,950	118,940	156,290
South Metro	134,200	159,140	195,650	231,960	298,470
Upper South Platte	7,710	9,759	- 12,450	15,350	21,700
Plum Creek	8,140	10,930	13,240	15,940	20,580
Box Elder Creek	950	1,100	1,200	1,400	1,700
Eastern Plains	4,150	4,600	5,600	6,600	8,200
Totals	1,505,290	1,692,725	1,860,444	1,944,369	2,465,450*

*This figure includes population projections outside the five county study area.

Based upon the land use analysis, impacts of development on water quality in specific areas can be anticipated. A series of flow charts in the Technical Report indicate the impacts of various land uses on water courses (see figures 5-3 through 5-7). A summary of these charts indicates that five activities are common to all forms of land use associated with urbanization: (1) clearing and grading of open landscapes; (2) installation of runoff facilities to accommodate storm and surface water runoff; (3) construction of impervious surfaces, such as roads, parking lots, and building foundations; (4) withdrawal of surface water and groundwater resources to provide for urban and agricultural demand; and (5) dense concentration of development, population, transportation, and utility systems in the developing areas.

These activities combine to create hydrologic complications including increased siltation of streams and ponds, increased urban runoff, increased flooding potential due to higher runoff rates, increased surface water storage areas and transmountain water facilities to compensate for loss of natural water resources. Such conditions warrant serious consideration of environmental impacts of urbanization and development of measures to mitigate the most serious impediments to the natural water resource system. The Technical Report presents development criteria related to water quality and to general environmental quality in Tables 5-7 and 5-8.

CONTROL MEASURES

Control measures for preventing water pollution and improving water quality in accordance with the 1983 goals consist of three basic approaches: (1) nonstructural, (2) structural, and (3) land application. Nonstructural control measures seek to control pollution with minimal capital cost and construction. Education programs, economic incentive, and land use regulations are considered nonstructural controls and focus on solving nonpoint source pollution problems. Structural controls are physical structures used for the containment, collection, and/or treatment of wastewater from point sources. Land application can be considered a combination of the other two approaches since it involves treatment of wastes to a certain level then utilization of that waste for beneficial uses on land surfaces.

Nonstructural Controls for Nonpoint Source Pollution

The two basic nonpoint sources of pollution are sedimentation resulting from disturbance of natural land surfaces and surface contaminants resulting from unnatural deposits on land and water surfaces. The latter includes litter, automobile wastes, residual chemicals from herbicides and pesticides, and fallout from air pollution.

Sedimentation can be reduced through practices that avoid erosion, confine sediments on site, and result in revegetation at the earliest possible time. Surface contaminants are very difficult to control since ordinances and "housekeeping" activities required to reduce them are difficult to enforce and expensive to maintain. The Technical

Report discusses nonstructural control measures for nonpoint pollution resulting from the activities of agriculture, construction, forestry, mining, and stream channel modification. (Stream channel modification results from diversion or flood control activities which can seriously affect water quality and aquatic habitat if not carefully controlled.)

Structural Control Measures

A wastewater control facility could include, but is not limited to, collection systems, household waste treatment systems, wastewater treatment plants including both conventional and land irrigation systems, water reuse systems, dams and holding ponds, infiltration-percolation ponds, and stream modifications. Structural controls deal with two basic facts of wastewater treatment: (1) Treatment systems do not destroy pollutants but simply change their state, phase, or method of conveyance, and (2) the removal of pollutants results in the production of residual waste that must also be treated and disposed.

Structural Control Measures for Nonpoint Source Pollution

Collection and subsequent treatment of urban storm water runoff converts this nonpoint source to an intermittent point source. A primary storm sewer system is intended to control pollutant discharges after minimal storms. A secondary storm sewer system to control flows from large storms would help reduce stream contamination in flood potential areas. Reducing the total amount of surface runoff by increasing the amount of permeable area in the drainage basin and modifying land drainage to prevent overland flow from entering storm collection systems would decrease contaminants entering streams. Land treatment of storm flows by irrigation and construction of infiltration basins would improve water quality before discharge into water courses. On-site retention of storm flows allowing for gradual seepage into aquifers and discharge into surface water bodies would also assist in improving water quality by filtering or settling out contaminants.

Structural Control Measures for Point Source Pollution

The EPA requires the consideration of three wastewater management techniques: (1) treatment and discharge into receding waters, (2) treatment and reuse, and (3) land application. Treatment and discharge is the common practice in the Denver metropolitan area, as it is throughout the nation. Treatment and reuse systems can involve reuse by the original user, reuse by a downstream user after treatment and discharge by the original user, or direct recycle by which the water never leaves the use/reuse system. The levels of trèatment required in each case depend upon the types of uses involved. Land application requires that the wastewater receive a specific level of treatment dictated by the land application system utilized.

Any biological wastewater treatment system will produce solid wastes, or sludge. The amount of sludge produced varies with the processes used, but can be generalized as 1,500 pounds per million gallons of wastewater. Mechanical treatment plants must include a sludge digestion system to stabilize waste, rendering it harmless and reducing its volume by approximately 40%. This results in solids of approximately 900 pounds per million gallons for disposal or reuse.

Sludge processing can be accomplished in a number of ways. The most common process is an aerobic lagoon system. As sludge accumulates in the lagoon it becomes anaerobic and is essentially digested without disposal or reuse becoming a problem. Most small plants in the 208 Study Area provide sludge digestion and air drying, after which the sludge is stockpiled and sold to community residents as a fertilizing aid and soil conditioner. Sludge injection is a process by which water is injected into the top six inches of soil used for forage crops the following season. The Metro system dewaters its sludge and hauls it by truck to the Lowry Bombing Site for incorporation into the soil. Costs analysis indicate that on-site air drying is the most economical system for plants with a capacity below 10 mgd. Above that amount costs are almost equal for all systems.

Treatment facilities have been investigated for three general wastewater sources: (1) municipal point sources, (2) urban runoff, and (3) agricultural runoff. Cost estimates represent complete project costs excluding cost of land (except for land application systems) with allowances for construction financing, contingencies, engineering and legal fees, and administrative costs. Estimated cost curves have been prepared by the consultants for municipal mechanical treatment processes and land application systems. These are available for review at DRCOG.

The control technologies for urban and agricultural runoff are not well defined so the following estimates should be used only as general guidelines. The cost of urban runoff collection, storage, and treatment according to literature sources ranges from $200 to over $10,000 per acre served. A more realistic range would be from $500 to $2,000 per acre. Most systems average $750 per acre. Operation and maintenance costs are projected at $15 per acre per year. Agricultural runoff treatment costs for the study area are projected at $6 per acre and $1 per acre per year for operation and maintenance if sedimentation ponds are used. Dry land agriculture will have an estimated capital cost of $5 per acre and $.50 per acre per year for operation and maintenance. Detailed cost figures are available at DRCOG for review.

A detailed discussion of land application systems appears in the Technical Report. Many conditions in the Denver area make land application very feasible: large areas of available land with suitable soils relatively close to wastewater sources; an ideal climate with mild winters, low precipitation, and high evaporation; and considerable need for and use of water for irrigation. The three land application processes applicable to the study area are (1) irrigation for crop production with evapotranspiration loss and little percolation through the subsurface avoiding direct discharge to surface water; (2) high-rate irrigation with the main objective of wastewater treatment and a secondary objective of crop production; and (3) infiltration-percolation intended to treat wastewater through natural processes as it recharges groundwater avoiding discharge to surface water.

Treatment Systems for MDSDD#1

The largest supplier of wastewater collection and treatment in the Denver metropolitan area is the Metropolitan Denver Sewage Disposal District #1 (MDSDD#1). The results of the Clean Water Program will directly impact the expansion and development of that facility by wasteload allocations and recommended treatment systems. A brief description of the existing system and proposed treatment alternatives will help illustrate the technical concerns of the 208 Plan.

Prior to constuction of the MDSDD#1 treatment facility, primary treated wastewater from the Denver Northside Plant was diverted into the Burlington/O'Brian Canal for immediate irrigation use or storage at Barr Lake northeast of Denver. The lake was an anaerobic lagoon which provided some further treatment, but increasing eutrophication resulted in significan offensive odors. During the irrigation season farmers were irrigating with effluent that had not undergone complete secondary treatment. After construction of the treatment facility for MDSDD#1, direct irrigation water from the South Platte and water used for irrigation from Barr Lake was significantly improved, but still of secondary effluent quality. In 1975 the EPA found Barr Lake to be highly eutrophic.

Despite the lake's eutrophic level, the state is proposing to develop the area into a state park. The upper portion near the influent will be a natural area; the lower portion is designated for primary contact recreation. This development will have considerable impact on treatment levels required for effluent discharged into the lake.

Two basic land use application systems were considered for MDSDD#1: (1) a land application system on publicly owned lands and (2) incorporation of the facility with the existing system of irrigated private lands. Use of public lands is not possible under the present ownership system, therefore the only realistic alternative is utilization of private lands. MDSDD#1 is required to have a treatment capacity of 185 mgd in the year 2000, which requires a total land area of 50,000 acres for any land application system. Although utilization of agricultural lands seems feasible, the following considerations are important: ownership of the effluent, responsibility for treatment, and potential discharge requirements for the South Platte River and existing ditches. The type of crops grown and projected recreational uses of water courses will determine effluent treatment levels.

To complicate the issue, determination of water rights and responsibilities of the Denver Water Board with regard to reuse facilities may seriously influence the activities of MDSDD#1 in the future. Although the facility would have to be capable of treating 185 mgd in the year 2000, it may only be treating 69 mgd after 1995, the projected date for initiation of the Denver Water Board potable reuse water facility.

REUSE/SUCCESSIVE USE OF WASTEWATER

Reuse is the subsequent use of water for the same purpose as the original use. Successive use is the subsequent use of water for a different purpose than the original use. The terms will be dealt with synonomously in this discussion and can be further defined according to the following categories:

1. Potable reuse: The direct reuse of wastewater effluent after special treatment for domestic purposes, including human consumption.

2. Industrial reuse: The reuse of wastewater effluent for industrial processes or cooling water after various degrees of treatment.

3. Urban irrigation: The irrigation of parks, golf courses, school yards, or boulevards with secondary treated wastewater.

4. Agricultural reuse: The reuse of effluent for agricultural purposes after a certain degree of wastewater treatment.

Wastewater Reuse Projects

Only a very small percentage of wastewater flow is presentrly reused, and most of it is reused for urban irrigation. Of the nine agencies within the study area that are presently using or have plans for implementing reuse projects in the future only one, the Denver Water Board, is applying wastewater to agricultural uses. Three agencies are planning reuse systems for urban irrigation, two for exchange of raw water or stream makeup, and three for agricultural reuse (agricultural runoff will be reused for agricultural purposes).

Urban irrigation uses do not affect the design or sizing of existing collecton systems since all wastewater must be collected and transported to a central treatment location whether or not it is to be reused. However, wastewater used for urban irrigation requires treatment above the secondary level. This treatment normally includes effluent filtration and additional chlorination.

An agricultural reuse system involves the discharge of a unit of wastewater into an irrigation ditch in exchange for a unit of raw water that is allowed to bypass the irrigation headgates and continue in the stream. An exchange system involves the exchange of a unit of wastewater discharged directly into an irrigation ditch for a unit of stream water diverted into the domestic water supply channel. The exchange does not have to be equitable in volume.

Northglenn, Thornton, and Westminster are planning exchange or agricultural reuse systems. These processes differ from conventional land application systems in that the agency discharging the effluent to the irrigation ditch is relieved of any further responsibility for the subsequent handling, use, and application of the effluent. That agency therefore is not in the farming business. Conversely, for land application systems, the original wastewater owner retains full responsibility for the treatment, handling, and application of the effluent. Some of the benefits of an agricultural reuse system over a land application system are as follows:

1. Total wastewater treatment costs are lower for the agency.

2. Recycling of valuable resources, such as nitrogen and phosphorous, is optimized.

3. Crop production is optimized because the primary purpose of applying the effluent to the land is irrigation rather than treatment of wastewater.

4. The farming business is maintained in the private sector.

5. Farmers are guaranteed a quantity of water not subject to weather conditions.

6. More use is made of the state's raw water supplies, and therefore the state has an improved water management system.

The concerns related to the agricultural reuse and exchange systems include the following:

1. Will the agricultural reuse wastewater be satisfactory for discharge as an irrigation spill if that same water was not satisfactory for direct discharge from the treatment plant?

2. What impact will the return flows from an agricultural reuse system have on stream quality?

3. Could dewatering of a stream reach occur since treatment plant discharges are directly into irrigation ditches instead of into the stream? In the agricultural reuse system this can be avoided since irrigators allow stream water to bypass the irrigation ditch headgates in exchange for the wastewater effluent. However, in the exchange system since volumes do not have to be equitable there is the possibility of lowering stream flow.

Reuse Projects Proposed by the City of Aurora

Having initiated an urban irrigation reuse project for watering its municipal golf course during the summer months, the City of Aurora plans to increase the urban irrigation system to irrigate parks and school grounds along the route of the pressure main delivering water to the golf course. In addition, the city is planning to implement industrial reuse systems for wastewater and potable water reuse through treatment and transportation of wastewater effluent to Quincy Reservoir. Potable reuse water would be mixed with raw water then treated at the water treatment plant prior to distribution within the city.

As an alternative to the reuse project expansions, the city is considering the sale or lease of nontributary return flows to downstream users. This would negate the reuses systems and additional water supplies would have to be developed for the city. The impacts of Aurora's water policy on the region are discribed in the Technical Report.

Reuse Projects Proposed by the Denver Water Board

The Denver Water Board has determined that urban irrigation and industrial reuse are not economically feasible due to the widespread distribution of potential reuse centers. It proposes a simple reuse system based on the exchange of used water at the sewage treatment plant outfall for less polluted water at the existing intakes. However, because of the Board's interpretation of the Blue River decree, it believes that water from the Blue River transmountain diversion must be reused for domestic purposes and that return flows may not be leased or sold to downstream users for agricultural purposes. Therefore, an agricultural reuse system for the Board's nontributary water is not considered feasible.

Through this process of elimination, the Board is planning a potable reuse system including a 1 mgd demonstration plant by 1980 and a 100 mgd reuse plan in the 1990s. Although the front end costs of the project are high compared to the cost of developing new water supplies in the near future, the costs appear to be equitable about 1998 with the reuse system becoming more economical than developing new supplies after that date.

The decision by the Denver Water Board may cause complications for the Metro Sewage District since it is legally bound to treat wastewater entering its facilities to required standards, while the Board will reuse only that portion of effluent required to meet its needs at peak demand periods. If Metro wastewater treatment processes are adjusted to be compatible with the Water Board's reuse plant, operation and maintenance costs of the Metro plant may be significantly higher than under normal expansion procedures. A detailed economic analysis of the proposed reuse system impact on existing and projected facilities should be undertaken to determine the most economical, efficient, and effective approach to wastewater treatment and reuse in the Denver metropolitan area.

Water Rights Aspects

The Colorado Constitution provides that the unappropriated water of every natural stream is the property of the public, subject to appropriation, and that the right to divert such water for beneficial use cannot be denied." Water, like land, is a finite commodity. Water rights in Colorado are considered real property and may be sold, transferred, and exchanged separately from the land over which it courses. In 1973 the state legislature amended state statutes to include as "beneficial use" minimum flows necessary to preserve the natural environment to a reasonable degree. Such appropriation of the very limited unadjudicated water supplies results in the assignment of junior rights thereby negating the ordinance's effectiveness. Lease or purchase of senior rights which could be transferred to new or alternate points of diversions could mitigate this problem and guarantee minimum stream flows in the more critical areas.

The water rights issue to too complex to treat at length in this summary report. The Technical Report discusses the problems of water use/reuse systems and the costs of obtaining water throughout the study area. Each circumstance of changing water use or water courses must be considered in the light of its legal aspects. The consideration of plans and recommendations for future water quality control will have to include these legalities.

WASTEWATER TREATMENT FACILITIES

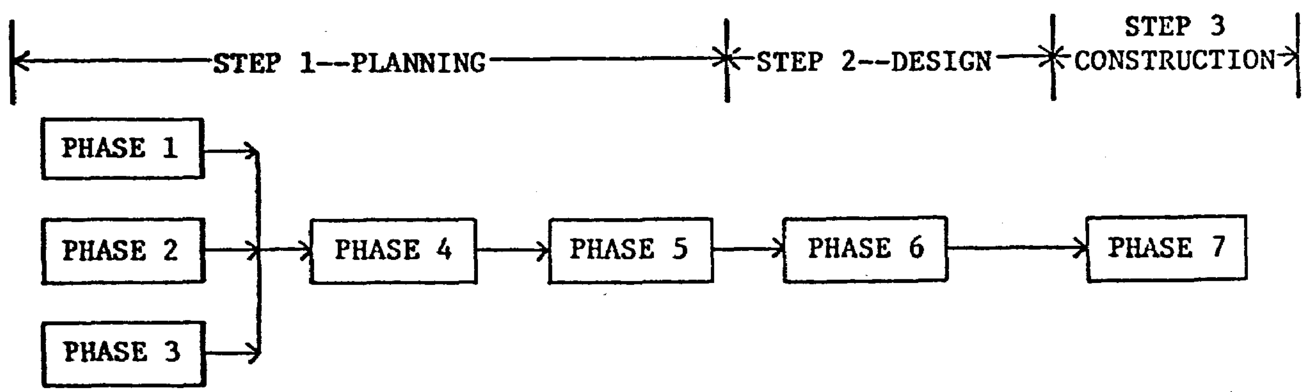
Wastewater treatment facilities are point sources for water pollution. Municipal and industrial facilities in the 208 Study Area have been studied and needs for upgrading them to meet the 1983 water quality goals have been analyzed. The technologies required to implement plan policies are directly related to facilities planning under Section 201 of PL 92-500.

There are 13 ongoing 201 facility planning studies within the metropolitan Denver area. DRCOG has developed guidelines that will insure facility planning consistency with the areawide 208 Plan. This consistency should be established in the early planning stages of the 201 program during consideration of basic planning elements such as population, land use, facility requirements, and alternative treatment strategies.

Facility planning involves a seven-phase process:

1. Develop effluent requirements.
2. Assess current conditions.
3. Assess future conditions.
4. Develop and evaluate alternatives.
5. Select plan.
6. Prepare design of treatment works.
7. Make arrangements for implementation.

These phases are divided into a three-step procedure within the 201 program as shown in the following schematic.



The Technical Report presents a detailed discussion of the seven phases stressing the importance of coordination on the regional level with implementation remaining basically at the local level. Recently agencies within the 208 Study Area have been exploring alternative methods of facility planning, still incorporating the basic planning procedures. These "interagency" plans include the following:

Northglenn System

The City of Northglenn proposes to "borrow" water from the Farmers Reservoir and Irrigation Company, treat it for potable use, collect the wastewater, treat it, and return it to agricultural use via Bull Canal north of Westminster. Domestic use is approximately 35% consumptive and the city has agreed not only to replace that amount, but to contribute an additional 10%. The makeup water could be derived from deep wells, urban runoff, and certain South Platte River water rights.

Westminster System

The City of Westminster proposes an exchange of effluent discharged into the Farmers Highline Ditch for an equal amount of raw water drawn from the source upstream of the discharge point. The system consists of pumping effluent from the Big Dry Creek plant to the Farmers Highline Canal. An equal volume of water will be diverted from the canal into Standley Lake, for which Westminster owns storage rights for its domestic supply.

Thornton System

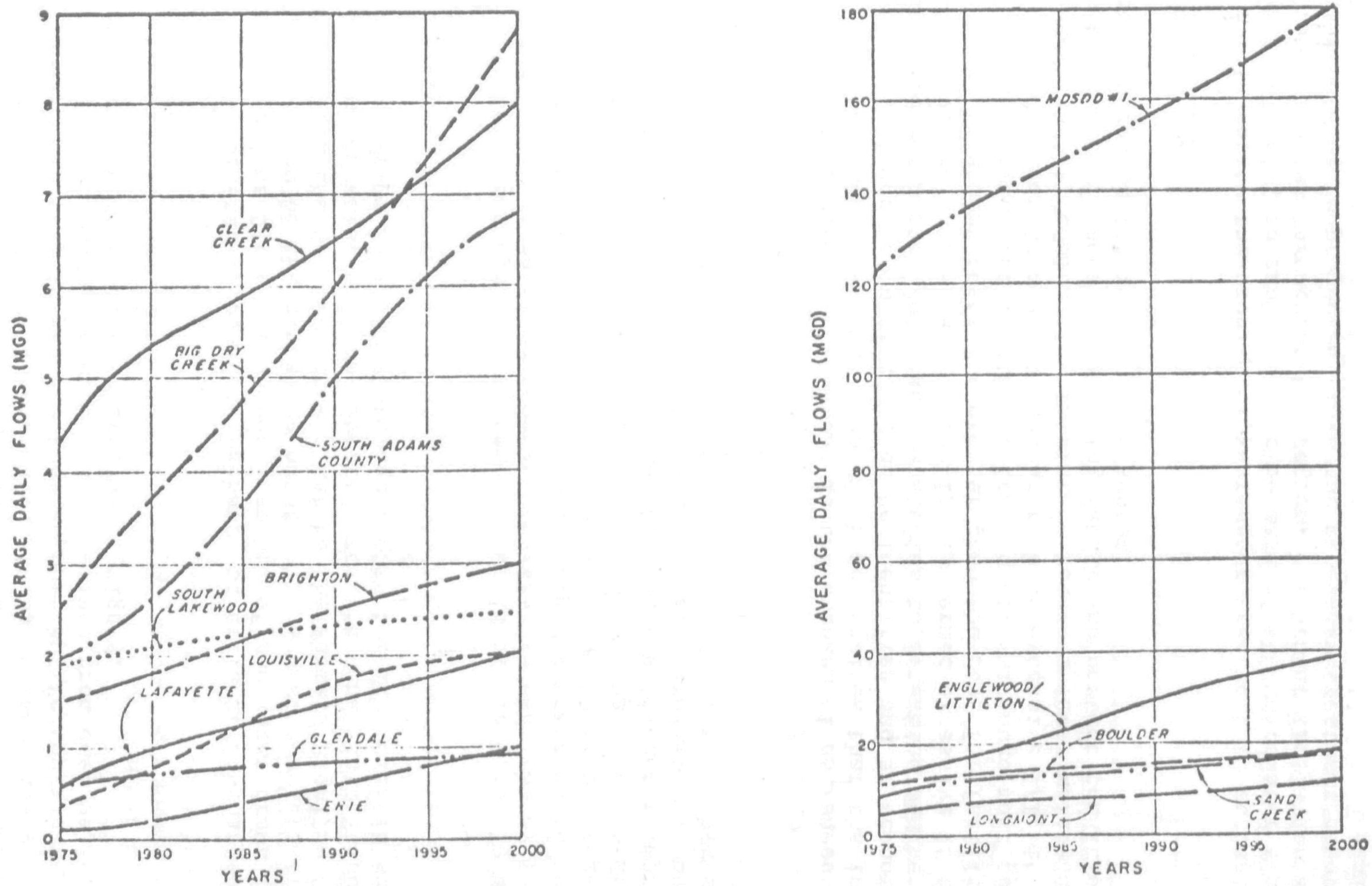
The City of Thornton proposes a system that would tie in with the Westminster plan. The volume of wastewater generated in the area of Thornton north of 100th Avenue would be pumped to the Big Dry Creek Basin for treatment at the Westminster plant. The effluent would be exchanged for water from the Farmers Highline Canal, which conveys part of Thornton's water supply. Through this method, Thornton can significantly improve both the quantity and quality of its water supply. Preliminary cost estimates are favorable and the system is recommended for further study.

Infiltration/Inflow Impact

Another aspect of wastewater treatment is the problem of extraneous water found in sanitary sewer systems. The 208 Plan requires that the infiltration/inflow (I/I) condition of a system be identified and an economic analysis performed during 201 planning studies to determine whether to treat or remove the excess water. The I/I is termed excessive if transportation and treatment costs are greater than the cost for facility improvement to correct the problem at its source. Although most communities in the 208 Study Area do not appear to have excessive I/I, it is recommended that all communities initiate a rigorous sewer maintenance program to locate I/I sources requiring repair and correct conditions to substantially reduce I/I in the sewer system.

Point Source Flows

In order to quantify the problem of wastewater treatment to accomplish water quality goals, an analysis must be made of the wastewater flows from various sources throughout the region. Treatment facilities are designed according to projected flows and necessary treatment capacities. Typical wastewater flows in the Denver area are 65 gallons per capita per day. Unit wastewater flows for industrial, commercial, public lands, and parks and recreation are projected on a per acre basis.



WASTEWATER FLOW PROJECTIONS BASED ON LOCAL TRENDS.

The illustration on page 22 depicts wastewater flow projections based on local plans for service areas throughout the study area. A consideration of both local and regional population forecasts and land use plans will aid in determining facility design criteria. The Technical Report presents basic design criteria for sewers, pumping stations and force mains, wastewater treatment plants, and land application systems.

Industrial Wastewater Treatment Facilities

The impact of industrial point sources upon water quality in the 208 Study Area has been investigated through computer modeling. Significant industrial pollution results from industrial process plants such as breweries and refineries and power plants employing water for cooling purposes. Pollutants from industrial process plants are primarily chemical in nature with bacterial levels present if sanitary sewage is combined with industrial waste. Power plants affect water quality primarily through thermal changes; however, if the cooling water contains pollutants before it goes through the cooling system, evaporation will concentrate those pollutants resulting in a degradation of coolant waters.

The proposed Colorado state water quality criteria restricts thermal pollution by limiting maximum and minimum temperature changes a discharging plant can bring about in receiving streams. The standards also stipulate that natural, diurnal, and seasonal fluctuations must be preserved. Computer data and Department of Public Health data provide the means by which maximum temperature and temperature changes within the river system are determined. The Technical Report presents a more specific analysis of industrial point sources in the Denver region and their anticipated future impacts on the area's water quality.

Industrial Residual Waste Disposal

The problem of industrial residual waste and waste oil disposal has never been adequately addressed in the United States. Very little information can be found about this subject. It would appear to be a major concern, however, since improper disposal of industrial liquid waste and waste oils can result in severe pollution problems many years after disposal. For example, Sand Creek recently experienced water quality problems from leachate related to an old industrial disposal site in the vicinity of Vasquez Street and Sand Creek.

The Lowry Bombing Range is serving as a landfill site for the City and County of Denver. Industrial wastes are dumped there and although information is not available for every year since this procedure started, approximately 5,000 gallons of waste were discharged on the site each day in the early stages of operation. At present 30,000 to 50,000 gallons per day are being discharged. Lowry is the only site within the Denver metropolitan area certified to receive liquid wastes and sludges.

At present the site is not threatening to contaminate surface or groundwater. However, continued use of the site at present rates could result in a long-term water quality problem. Development controls should be initiated to minimize construction in the landfill area and prevent the drilling of wells in adjacent groundwater systems.

NONPOINT SOURCE POLLUTION

In the early pages of this summary we mentioned that increasing nonpoint sources of pollution may stand in the way of accomplishing 1983 water quality goals even if mechanical systems are upgraded to treat effluent to acceptable discharge levels. Currently, nonstructural controls are considered the most feasible approach to dealing with nonpoint sources. These controls emphasize "no-cost" programs including good housekeeping practices, public education, and legislation.

The introduction of certain amounts of sediment, organic materials, and nutrients into the water regime is a natural phenomenon and, in fact, is essential to an optimum ecological balance. However, increased population concentrations and changing land use patterns have accelerated these natural processes and introduced toxics to the environment through the use of fossil fuels, detergents, pesticides, and industrial chemicals. Phosphate, fecal coliform, and fecal streptococci have been identified as the most serious problems associated with urban runoff.

Septic tanks and landfills are of concern as sources of nonpoint pollution. Although septic tanks have not been documented as a serious problem (probably due to the lack of sufficient data), mountain systems appear to present more of a problem than plains systems due to thin soils, steep slopes, and geological conditions. Where septic systems fail in the mountains direct discharges into the aquatic environment result in pollution similar to that created by improperly treated sewage including constituents such as BOD, pathogens, phosphate, ammonia, and nitrate.

Landfills in the study area have been constructed in the floodplains of Cherry, Sand, and Clear creeks and along the South Platte River. The present potential contamination problems result from water and other substances leaching through the fill into groundwater supplies and into surface streams. Properly designed landfills will not produce leachate, but improperly designed sites can result in leachate from infiltration of precipitation, percolating water entering from adjacent areas, or direct contact with the groundwater table.

Nonpoint source loads are measured in terms of pounds of constituent build up per day on impervious surfaces. This somewhat understates the actual amount of pollutant loading because runoff is not a daily event. Assuming a maximum buildup rate of 30 days in the Denver area due to its semi-arid climate, the amount of pollutants carried to a receiving stream following a storm could produce the highest contamination levels possible in spite of point source controls.

The Technical Report discusses the pollutant levels and control measures recommended for water quality control for both point and nonpoint sources since a combination of the two controls will be essential for meeting the 1983 water quality goals. Specific controls for urban runoff in existing and developing areas, septic tanks, landfills, and agricultural return flows are presented in the report. However, the lack of specific information for nonpoint sources with in the study area limits the analysis of anticipated effects of remedial actions. The report also describes specific nonpoint data needs for the more highly urbanized basins.

WATER QUALITY PLANNING ALTERNATIVES

As a result of the research and analyses of the Clean Water Program, a set of control strategies was developed and submitted to the Water Quality Management Task Force for review. The findings were also presented at public hearings for citizen input. About that time the Water Quality Control Commission proposed a new series of water use classifications and water quality standards for Colorado streams.

When it was found that the proposed control strategies would not meet the 1983 goals, a computer model (Hydrocomp) was employed along with other analytical methods. The resulting control strategies, presented in the Technical Report and summarized here, are based on present and anticipated pollution impact on stream reaches within the study area, actions required to improve water quality to desired levels, cost of such actions, and practicality of accomplishing the desired goals considering stream condition and anticipated water uses.

Wasteload Allocations

Wasteload allocations are necessary for controlling discharges which may result in exceeding the stream's capacity to serve other beneficial uses downstream. The four key points in the wasteload allocation process are (1) beneficial uses, (2) right to discharge substances, (3) distribution, and (4) stream capacity.

Current stream classifications are as follows:

A_1--primary contact recreation (cold water fishery)

A_2--primary contact recreation (warm water fishery)

B_1--secondary contact recreation (cold water fishery)

B_2--secondary contact recreation (warm water fishery)

C --agricultural use

The Water Quality Control Commission has proposed a reclassification system based on eight beneficial uses. The figure on page 26 indicates the beneficial water use combinations for each stream within the study area.

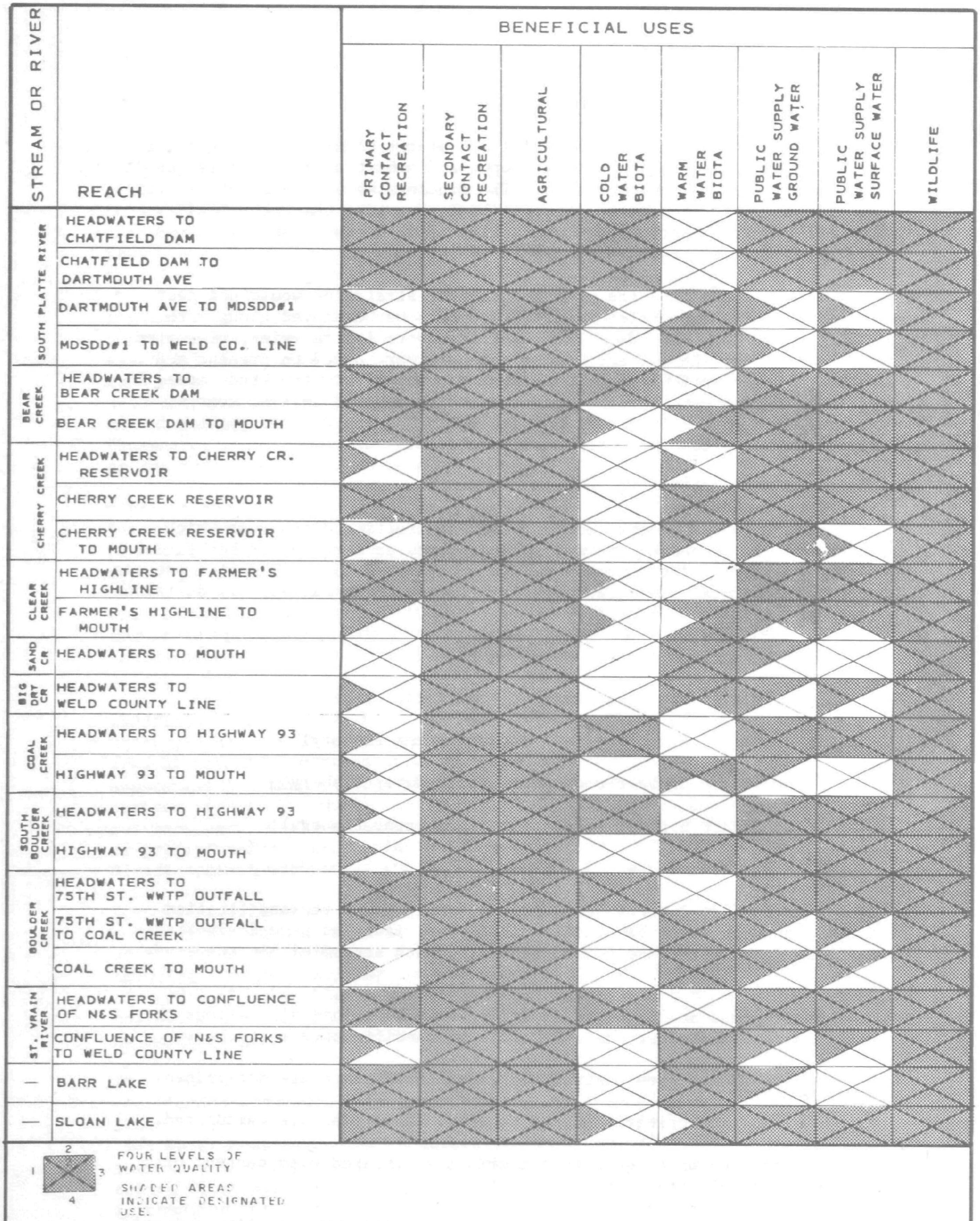
Four basic steps are involved in determining wasteload allocations to meet the required water quality levels of specific stream reaches.

1. The beneficial uses desired for each stream reach are determined.

2. Water quality criteria needed to allow those uses are calculated.

3. The required water quality criteria are compared with current or expected pollutant levels.

4. Wasteload reductions necessary to satisfy the water quality criteria are computed.



WATER USE COMBINATIONS

Wasteloads are then allocated to industrial and municipal dischargers.

Computer Model. A computer program was used to make predictions about instream water quality for the major portions of the metropolitan area. The streams included in the program are the South Platte River from the foothills to Weld County, Sand Creek, Clear Creek, Bear Creek, and Cherry Creek. Known discharges and development patterns, climatological conditions, stream flow, and stream quality for the period 1969 through 1973 were entered into the model. Appropriate adjustments were made so the model would simulate the instream water quanatities and qualities occuring under historic, climatological, and development patterns for the five model streams. This "calibration" assures that the program will reasonably estimate future water quality conditions. Different pollutant levels from point and nonpoint sources were assumed and fed into the program. The model then showed the water quality conditions likely to occur from the different wasteload allocations.

Hand Modeling. Hand modeling was performed for streams (1) where water quality data was insufficient for computer modeling and (2) where stream conditions were far less complex in relation to intensive urban development with accompanying point and nonpoint source discharges. Hand modeling followed the basic computer methodology.

Wasteload Allocation Methodology

The methodology to determine allowable pollutant discharges is complex and relies on the availability of accurate water quality data. The following five methods are the most commonly accepted.

1. *Eaual treatment levels.* Downstream water quality levels are achieved by assigning equal treatment levels to all upstream dischargers. If higher water qualities are desired in an upstream reach, facilities above that reach must further reduce their pollutant levels.

2. *Cost effective method.* This system essentially minimizes total cost to the region by placing the greatest restrictions on facilities that can reduce pollutant loadings most economically. Adequate institutional arrangements are necessary to ensure that all entities generating wastewater pay their fair share of treatment costs.

3. *Water quality impact method.* This method is essentially the reverse of the first method in that allocations start upstream and work down to the low end of the basin. The most stringent treatment levels are assigned to facilities most responsible for water quality degradation.

4. *Ownership method.* The most stringent requirements are assigned according to the amount of discharge created by each facility with private dischargers (usually industries) having to remove the bulk of the pollutants. Costs are spread throughout the nation in the form of higher product prices.

5. *Area based system.* This system establishes a total allowable wasteload for a defined area, usually an undeveloped area. It often serves as an indirect form of land use planning, allowing area development only to assigned wasteload levels.

The equal treatment level method has been used to develop wasteload allocations in the 208 Study Area because of the existing institutional arrangements, the preponderance of municipal dischargers, and intensive development throughout the region. The following procedure was followed:

1. Starting at the lowest point of the basin, existing or anticipated pollution levels in each stream reach were compared with the level of water quality desired.

2. Using a computer simulation or hand model, pollutant reductions necessary to achieve the desired water quality were determined.

3. Reduced discharge loads were entered into the computer to determine if water quality criteria would be met. In not, load adjustments were computed and the model rerun until the desired water quality could be met.

4. When water quality goals were achieved by the model for the downstream reach, the next highest reach was computed. Only facilities upstream of the particular reach will be required to make additional pollutant reductions to achieve desired standards.

5. All tributaries discharging into the main stem stream were submitted to a similar technique as the method was employed for each reach. If the tributaries are assigned a higher use than downstream waters, a higher level of treatment may be called for in the upstream reaches.

6. The treatment processes necessary to achieve the water quality goals were determined for each municipal treatment facility and a cost estimate developed for the construction and operation of those treatment processes.

7. If water quality desired cannot be met by control of point sources, specific water quality criteria unachieved will have to be described and a decision made as to whether or not control of nonpoint sources is likely to meet those criteria.

The wasteload allocations required to meet desired water quality will depend partially on the time period for which they are designed. The Colorado Department of Health has determined that the design period will be a low stream flow period of seven consecutive days, occurring once in 10 years on the average. These periods in the Denver area will likely occur during the period of July through September when water temperatures are higher and water qualities lower than average.

Another consideration in determining the effectiveness of wasteload allocations and alternative control measures is the amount of inflows and associated water qualities entering the basin through surface streams from other areas or groundwater recharge to surface streams.

Allocations According to Stream Classification Alternatives

Four stream classification alternatives were considered for the Denver metropolitan region. Alternative 1 represents the highest possible water quality in all stream reaches throughout the area, alternative 4 represents the lowest. Alternatives 2 and 3 are positioned between the two. Two methodologies for developing wasteload allocations were applied to all four alternatives to achieve the specific water qualities desired. The first method was the equal treatment method, the second was the cost effective method. The Technical Report contains a series of figures illustrating the results of this analysis for the Denver metropolitan area and for the northwestern areas of Boulder, Longmont, Lafayette, Louisville, Erie, Niwot, and Superior.

Equal Treatment Method

Using this method alternative 4 water qualities generally can be attained by using secondary treatment, including reoxygenation. Converting ammonia to nitrate at the Englewood/Littleton and South Lakewood wastewater treatment plants can bring the levels into conformance with alternative 4, but for about 4 months each year they will also have to remove ammonia through a higher level of treatment. To meet alternative 3 water quality goals, all treatment plants within the study area will have to convert ammonia to nitrate. Reoxygenation will also be required for all treatment plants.

Alternative 2 requirements would necessitate a further reduction in ammonia levels. Conversion of ammonia to nitrate is not appropriate since low instream levels of nitrate are needed to meet public water supply criteria. The plants would have to employ a process of nitrogen removal.

Alternative 1 requires that discharges of ammonia, nitrate, and phosphate be kept to a minimum. This can be done by nitrogen and phosphate removal processes.

Estimated costs and projected pollutant reductions and limitations are discussed in the Technical Report.

Cost Effective Treatment Method

The results of the cost effective method for alternative 4 criteria are similar to the equal treatment method results. In order to meet the goals of alternative 3, only the Englewood/Littleton, South Lakewood, Metro Denver, Sand Creek, and Golden sewage treatment plants will have to convert ammonia to nitrate as will Sand Creek major industry. In addition Englewood/Littleton, MDSDD#1, and Sand Creek treatment plants will have to treat wastes to a higher level to remove more ammonia four months out of the year.

The cost effective approach to alternative 2 requires that Englewood/Littleton, South Lakewood, Glendale, and Golden sewage treatment plants convert ammonia to nitrate. Only MDSDD#1 and Sand Creek will have to remove nitrogen in order to meet public water supply criteria.

Alternative 1 requires phosphate removal from all major point source effluent. Conversion of ammonia to nitrate is required for South Lakewood, Glendale, Sand Creek major industry, and the Golden sewage treatment plant. Nitrogen removal is required only at Englewood/Littleton, MDSDD#1, and Sand Creek sewage treatment plants.

Mountain and Plains Area Allocations

The mountain areas will be assigned wasteload allocations as water quality criteria are met in the downstream reaches. These allocations will affect wastewater treatment plants in portions of Jefferson and Boulder Counties.

The plains area consists of approximately 1,600 square miles east of the metropolitan area. Because streams in the plains area originate in the plains and are not continuously fed by high mountain snowmelt they have only intermittent flows. Flash floods resulting from summer thunderstorms account for most of the stream flow. Under these conditions acquatic life cannot be sustained nor are recreational ammenities likely. In addition, population is sparse and dry land agriculture is the primary land use. For these reasons no attempt was made to model water quality levels in these streams. Secondary treatment levels are assumed to be sufficient for future water quality planning.

Wasteload Allocation Cost Estimates

Mechanical and land application systems have been considered as the most feasible methods for reducing pollutants in study area streams. Based on a series of 14 possible effluent qualities (limitations), both systems have been considered for each of the four stream classification alternatives.

Five basic mechanical processes, representative of those currently used to remove various contaminants, provided reliable capital and operation and maintenance (O&M) cost information. They were examined in different combinations to produce various effluent qualities. The processes were (1) secondary treatment, (2) filtration, (3) nitrification (ammonia removal), (4) selective ion exchange (nitrogran removal), and (5) phosphorous removal.

Cost estimates were prepared for 14 treatment facility locations and for each of the 14 levels of effluent quality using cost curves developed for capital and O&M costs for each of the five basic processes. Capital costs were estimated based upon wastewater flow projections, existing facility capacities and treatment processes, and the degree of treatment required. O&M costs were estimated based upon average daily wastewater flow projections. The information was applied to a computer model which calculated the estimated annual capital and O&M expenditures from 1981 to 2000 for each of the 14 facilities. The program also calculated the present worth of the total cost of treatment for this time period. The table on page 30 indicates the present worth and per capital costs for the equal treatment method.

TABLE 10-17. Present Worth and Per Capita Costs of Equal Treatment Methodology (Assumes no federal funding).

Municipal Treatment Facility	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
	Pres. Worth ($ x mil.)	Avg. Cost ($/pe/yr)	Pres. Worth ($ x mil.)	Avg. Cost ($/pe/yr)	Pres. Worth ($ x mil.)	Avg. Cost ($/pe/yr)	Pres. Worth ($ x mil.)	Avg. Cost ($/pe/yr)
1. Englewood/ Littleton	57.2	24.7	48.1	20.6	41.9	17.7	41.9	17.7
2. South Lakewood	8.1	37.4	6.8	32.1	6.2	26.4	6.2	26.4
3. MDSDD No. 1	191.3	14.4	158.0	10.5	134.7	9.6	97.1	6.5
4. Golden	9.9	35.7	9.9	35.7	7.2	24.9	6.6	22.9
5. Aurora	30.0	24.7	24.9	20.2	21.4	17.1	16.0	12.3
6. South Adams County	13.8	33.9	11.5	27.7	10.0	23.5	7.5	16.8
7. Brighton	7.7	38.1	6.3	30.7	5.6	26.8	4.1	18.6
8. Big Dry Creek	18.0	35.2	15.3	29.8	15.3	29.7	10.8	20.3
9. Boulder	29.3	22.4	24.2	18.1	12.8	9.1	11.2	7.7
10. Longmont	16.4	23.3	12.8	18.2	10.5	14.7	6.2	8.5
11. Erie	3.2	63.8	2.6	50.1	2.8	53.6	2.2	42.4
12. Layfayette	7.9	58.7	6.9	49.9	6.9	49.9	6.1	43.7
13. Louisville	5.3	39.3	4.2	30.6	4.2	30.6	3.5	24.4
14. Glendale	2.4	29.5	1.8	21.0	1.6	18.2	1.6	18.2
15. PLAINS (1)	1.3	18.0	1.3	18.0	1.3	18.0	1.3	18.0
16. MOUNTAINS (1)	5.0	23.8	5.0	23.8	5.0	23.8	5.0	23.8
TOTALS	406.8		339.6		287.4		227.3	

(1) Information obtained from the Mountains and Plains study.

The main concern related to land application systems is the possible harmful affects of wastewater pollutants on vegetation, soil, surface water, and groundwater. Crop characteristics, geologic formations, groundwater quality, and wastewater constituents must be carefully considered in the design of a land application system. The effluent quality anticipated from each land application system suitable for the Denver area can be equated to one of the 14 treatment levels as follows:

Land Application System	Treatment Level
Irrigation	14
High-rate irrigation	6
Infiltration-percolation	6

Because of the many variables involved, land application costs have not been developed. An estimate of probable costs was made for each system as follows:

Irrigation or agricultural reuse. Normally considered the most efficient land application system, agricultural reuse costs can be greately affected by the water rights issue. In general, costs associated with implementing the process are directly related to the water quality required by the receiving irrigation system. In most instances good secondary water quality is all that is needed; but if the system includes a recreation site, such as Barr Lake, much higher water quality is required. The land application costs, therefore, can range between 50% and 120% of an equivalent mechanical process yielding the same water quality.

High-rate irrigation. This process is generally far more expensive than a conventional treatment facility due to the cost of purchasing land to accommodate high-rate irrigation. Costs range between 120% to 200% of the mechanical process yielding the same water quality.

Infiltration-percolation. This process is normally feasible only along streams in the study area since it requires about a 15 foot depth of sand and gravel to operate. If proper land is available, costs can range between 70% and 100% of the mechanical process.

Wasteload Allocation Violations

Point source wasteloads have been allocated for periods of low flow. An analysis was made to determine how often the desired criteria for each stream classification alternative would not be met by control of municipal and industrial wastes. For alternative 1, the highest classification, fecal coliform levels cannot be met for 9 to 12 months without both point and nonpoint source controls. Although phosphate levels can be substantially reduced through point source controls, desired water quality cannot be achieved due to nonpoint source pollution.

For alternative 2, point source controls cannot meet the more stringent fecal coliform levels for 4 to 12 months. Phosphate levels will remain higher than desired even with both point and nonpoint source controls. Alternative 3 criteria can be met with the exception of fecal coliform resturctions. Nonpoint source controls may mitigate this condition.

Alternative 4 corresponds most closely to the present situation. This criteria can be met throughout the year through point source control alone, except in upper stream reaches where very high water quality is specified. This exception pertains to all four alternatives. Desired water quality in the lower stream reaches can be met with the exception of fecal coliform, levels for which will be exceeded more than six months of the year as a result of nonpoint source pollution.

ACHIEVABILITY OF 1983 GOALS

The major objective of this study was to determine whether or not the metropolitan Denver 208 Study Area can achieve the goal of fishable/swimmable waters by 1983. The water quality goals call for four basic water uses: (1) fish propagation, (2) primary contact recreation, (3) secondary contact recreation, and (4) wildlife protection. Realizing that the national goal may not be possible in some areas, federal legislators included the statement "where attainable" in the legislation. This has been interpreted to mean that if background levels of pollutants in stream reaches do not meet the specific criteria, these streams may be excepted from the goal. However, background levels are assumed to result from natural sources, not from land development and urbanization.

To achieve the national goal, not only the low flow periods must be considered in criteria development. Some reasonable design flow condition for the entire year must be considered. For the Clean Water Program analysis the year 1972 was used since it has been stipulated as being drier than most years and the necessary meteorological and hydrological data are available for analysis.

Point and Nonpoint Source Controls

Alternative 1 is very similar to the national goal requirements for water quality. Effluent qualities that will achieve alternative 1 in the study area will meet the conditions specified for the 1983 goal. However, to accomplish this pollution from nonpoint sources would have to be reduced either through structural or nonstructural controls. Based on computer generated information this would require a 75% reduction in diffuse pollution for the Denver metropolitan area and 60% for the northern areas. It is estimated that fecal coliform and phosphate, the major violators of water quality criteria, can be reduced 25% to 35% with an aggressive program of nonstructural controls including the following:

1. Animal control to reduce fecal coliform in urban runoff.
2. On-site detention ordinances to allow sediment settlement and help control phosphorus.
3. Catch basin maintenance to help control phosphorus.
4. Street sweeping programs to reduce both pollutants.
5. Ordinances requiring parking lot cleaning to limit both pollutants.
6. Ordinances against phosphate detergents.

7. Leaf collection programs to help limit phosphate and BOD and to reduce the costs of catch basin and storm sewer maintenance.

The table on page 34 summarizes the total annual costs for achieving the 1983 national water quality goal. The total estimated cost for the Denver metropolitan area is $292,000,000 per year.

REGIONAL MONITORING SYSTEM

Water quality monitoring for the 208 Study Area is being considered for (1) groundwater in special problem areas; (2) continuing research for nonpoint pollution sources, especially urban runoff and agricultural return flows; and (3) instream monitoring which is the current major concern for determining regional trends of water quality and wastewater control. The pupose of the monitoring system is also threefold: (1) to assist in defining water quality problems, (2) to assess progress being made in meeting 208 planning goals, and (3) to provide a data base for updating and improving the Hydrocomp Water Quality Model.

The proposed sampling network consists of 30 sampling sites with 4 continuous sampling stations and 26 "grab" sampling stations. Infrequent sampling in the mountain areas of Boulder and Jefferson counties is also proposed. Each of the continuous sampling stations would be associated with a continuous stream flow gaging station. Frequency of sampling would vary from twice a month to six times a year for most stations. The Technical Report describes each of the sampling station locations and identifies the types of problems to be monitored.

Most of the proposed network stations are currently being sampled by agencies within the area, including the Department of Health, City and County of Denver, Corps of Engineers, and the USGS. The proposed system would result in approximately nine new stations. The design is intended to be flexible with respect to sampling locations, constituent samples, and frequency of sampling.

ENVIRONMENTAL ANALYSIS

Throughout the two year study for the Clean Water Program environmental considerations were uppermost in consideration of water quality control. Implementation of the 208 Plan will result in long-term positive environmental impacts throughout the region. Cleaning up the water will yield benefits in recreation and water supply along with improved aesthetics and other intangible "quality of life" considerations.

Short-term negative impacts may be experienced at the local level where construction of new facilities or expansion of existing facilities is required to meet the 1983 goals. Air pollution, noise pollution, and increased sedimentation of water courses are some of the temporary impacts to be expected. However, control measures to contain these impacts onsite with early clean-up and revegetation can mitigate these problems. The Technical Report discusses environmental impacts of each of the four alternatives on a basin-by-basin basis.

Summary of Total Annual Costs for Achieving 1983 National Goal

Basin	Nonpoint Sources Structural ($\$10^3$/yr.)	Nonpoint Sources Nonstructural ($\$10^3$/yr.)	Point Sources Structural ($\$10^3$/yr.)	Total ($\$10^3$/yr.)
	Urban Runoff			
Chatfield	3,200	500	0	3,700
South Platte	70,600	10,000	24,300	104,900
Bear Creek	11,200	1,500	0	12,700
Cherry Creek	14,500	2,200	300	17,000
Sand Creek	20,700	4,500	3,400	28,600
Clear Creek	22,600	3,600	1,100	27,300
Big Dry Creek	8,300	1,700	1,500	11,500
Coal Creek	7,400	1,000	1,500	9,900
Boulder Creek	18,900	3,000	3,000	24,900
St. Vrain Creek	54,000	1,000	1,900	8,300
Eastern Plains	0	0	200	200
Mountain Areas	0	0	200	200
	Agriculture			
Region	41,000	2,000	-	43,000
Total	224,000	31,000	37,000	292,000

FINANCIAL PROGRAM

The objectives of the 208 financial program are (1) to provide an assessment of major financial issues and current financial planning for water quality in the Denver metropolitan area, (2) to provide criteria and a methodology for financial evaluation of water quality alternatives, and (3) to produce a financial plan consistent with the requirements of PL 92-500 and the needs of the 208 Study Area. The following major financial issues evolved during the 208 Financial Workshop held in May 1976 and from interviews with agency officials: (1) The availability of capital funds through grants or bonds, (2) the objectives of water quality planning, (3) the relationship between the planning agency and the management agencies, and (4) the interrelationship of management agencies with regard to consolidation or joint financing.

Much of the work involved compiling short-term (5-year) financial plans for major wastewater treatment agencies and assessing financial feasibility of the proposed technical strategies. Evaluation criteria consisted of cost, financial feasibility, and financial arrangements. Cost criteria are applied on a regional basis; financial feasibility and financial arrangements are applied on an individual agency level.

The financial plan will include a detailed 5-year program and a general 20-year program for treatment facilities scheduling and identification and timing of financial measures needed to implement the areawide water quality program. Coordinating individual agency plans with the regional plan will be a major part of the financial program as it relates to both short-term and long-range planning processes. The financial problems of individual agencies will have to be addressed on the local level and will remain the responsibility of management agencies.

The Technical Report discusses the financial requirements of PL 92-500 and the problems in meeting those requirements within the institutional structure of the Denver metropolitan area. The financial capabilities of the management agencies is a major consideration in meeting the 1983 and 1985 water quality goals. Seven major wastewater treatment agencies were analyzed with regard to present financial capabilities to (1) identify potential financial constraints on implementing the water quality alternatives and (2) provide a basis for comparison of agency financial plans and the financial implications of the water quality planning alternatives. The seven agencies, representing the major amount of revenue and expenditure for wastewater facilities in the 208 Study Area, were the following:

1. Wastewater Division, Boulder
2. Wastewater Management Division, Denver
3. Department of Utilities, Englewood
4. Sewer Department, Longmont
5. MDSDD#1, Metro
6. South Adams County Water and Sanitation District
7. Department of Public Works, Westminster

The same information will be collected for the remaining treatment agencies within the study area. Information derived from these analyses is presented in the Technical Report.

As a result of the analysis of the current financial situation, a financial planning overview was developed for the 208 planning program. The first step in the planning process is to define planning assumptions including (1) projections of community desires, (2) the service population, (3) government requirements for treatment and other aspects of facility operation, and (4) the content of regional plans and the need to conform to these plans. The second step is to define capital and operating requirements necessary to administer and construct new facilities and/or renovate existing facilities and implement new treatment processes to meet the desired water quality criteria of the community. Step three involves the consideration of alternative strategies required to achieve step two. The most cost effective alternative should be identified and pursued. The fourth and final step is to identify the funding sources available to implement the proposed strategy.

Financial Strategies

The primary revenue sources upon which agency financial strategies will be based are (1) federal construction and Community Development grants, (2) proceeds from revenue bond sales, (3) connection and plant investment fees, and (4) service charges. With the exception of Metro which does not collect connection and plant investment fees, each of the agencies analyzed plans to utilize all four funding sources. Denver only is considering revenue sources it has not previously used.

Management personnel of area agencies are convinced that they will be required to meet increasingly stringent treatment standards. They are concerned about potential financial limitations and constraints on their capabilities to meet these standards. A major constraint is their capability to finance capital investments. The elimination of grant funding is discussed in the Technical Report. Major concerns about this funding source are (1) the dollar amounts available and (2) the eligibility of management agencies to receive grants. Although the amount of funding has not been established by law, the Director of the EPA Office of Grants has estimated that the Denver area would be allotted $22 to $42 million per year during the 1978-80 period. The estimate for the entire state is $40 to $70 million annually, 55% to 60% of which would be allotted to the Denver area.

Agency eligibility to receive grants is not considered a long-term constraint since those who have not utilized user charges and industrial cost recovery systems required by PL 92-500 are now developing those procedures.

Financial Criteria and Evaluation Methodology

Cost effectiveness and cost benefit criteria were applied to the financial analysis since effectiveness and benefit are major concerns of local officials and federal legislators. In order to apply cost effectiveness criteria to the evaluation of water quality control alternatives clearly defined water quality objectives are needed. For municipal wastewater treatment facilities the requirement of PL 92-500 is only that the "best practicable" technology be implemented by 1983. The result of applying cost effectiveness criteria to the alternatives may be the modification of water quality objectives to more attainable levels.

The cost benefit analysis differs from cost effectiveness primarily in that it does not relate to a specific objective. Although simple in theory, this procedure is difficult to apply to water quality control measures because of the difficulty in quantifying the value of water quality. This analysis was conducted by a process of elimination by which alternatives producing benefits of less value than other alternatives were discarded.

The methodology used to evaluate the financial feasibility of the financial plan alternatives included the following steps:

1. Selection of the most cost beneficial alternatives.

2. Development of preliminary financial plans for each alternative.

3. Financial data review by agencies that would be affected by plan implementation.

4. Incorporation of agency input with preliminary plans.

5. Presentation of preliminary plans to Water Quality Management Task Force for evaluation.

The financial arrangements methodology consisted of evaluation of the following criteria for each agency.

1. Legality. Does existing legislation permit this form of revenue? If not, can legislation be implemented soon enough to support the financial plan without delaying total plan implementation?

2. Costs.

3. Flexibility. Can revenue sources be adapted to new measures?

4. Reliability. Will revenue sources continue or are they dependent upon annual legislative action?

5. Political acceptability.

6. Compatibility with existing revenue sources.

Preliminary Financial Plans

Preliminary financial plans should delineate agency responsibility in the following areas; (1) control of point source pollution, (2) monitoring and regulation, and (3) continued planning. Issues of capital cost projections, debt service, operation and maintenance and administrative costs, service charges, borrowing, and other major revenues and expenditures should be addressed in the plans. Upon completion of alternative plan selection a more critical evaluation of financial arrangements will be required to determine the feasibility of implementing the selected alternative.

REVIEW OF THE 208 CLEAN WATER PROGRAM

The Clean Water Program is a complex effort involving the participation of governmental agencies and citizens throughout the Denver metropolitan region. Its goal is not only to respond to federal legislation mandating water quality improvements by 1983, but to accomplish state and local goals of improved environmental qualities. Planning, management, and financing are the basic concerns of the program. The most cost effective and cost beneficial methodologies will be employed to accomplish the stated goals.

New technologies and processes will have to be considered, especially in dealing with the problems of nonpoint source pollution in urbanized areas. Consolidation of existing wastewater treatment systems and cooperation among management agencies will facilitate the reduction of point source pollution on a regional basis. Establishment of an areawide planning agency will expedite problem analysis and funding solutions on both the regional and local levels. Any attempt to reorganize governmental activities results in a feeling of insecurity and loss of autonomy for the agencies affected, but through close coordination and constant communication with all agencies involved the 208 Clean Water Program continuing planning process should provide a smooth transition into a well managed, highly effective water quality maintenance program.