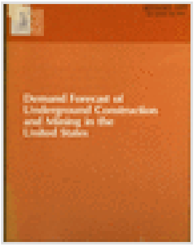

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Subcommittee on Demand Forecasting
U.S. National Committee on Tunneling Technology
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PREFACE

The underground construction and mining industries of the United States do not have a usable, centralized source of demand forecasts for their products and services. This contributes to a number of problems. Individual companies experience planning difficulties, government agencies often are forced to develop long-range schedules without complete information about the activities of other agencies, and the entire industry encounters cycles of boom and bust that might be avoided if more were known about what lies ahead.

The U.S. National Committee on Tunneling Technology has recognized, for some time, the need for a source of underground construction demand data. Its Subcommittee on Demand Forecasting has studied the problem, and this report represents the Committee's first step toward meeting the need. The approach used was to survey those who would benefit most directly from a compilation of demand data. Letters from the Subcommittee to key members of the industry, asking for information about future construction projects, met with an overwhelmingly favorable response. Members of the Subcommittee have compiled the information presented here.

The Subcommittee on Demand Forecasting is grateful for the help from the commercial and government sectors that made this report possible. It is the Subcommittee's hope that htis demand data will be useful to government agencies and to all other segments of the industry. If the data prove to be of value, and if it appears that a more comprehensive forecast would provide greater benefits, the Subcommittee may undertake such an effort at an appropriate time.

Because the work going into this report has occurred over a considerable period, the present Subcommittee members should not take all the credit. Past members who deserve special mention for having contributed their ideas and invested their personal time include Ellis L. Armstrong, Louis E. DeCamp, Thomas J. O'Neil, Samuel Taradash, and Frank T. Wheby.

CONTENTS

CHAPTER 1

INTRODUCTION

BENEFITS OF DEMAND FORECASTING

Knowledge of future demand is a useful planning tool for any industry. Such forecasts are particularly important to the underground construction and mining industries, because they require specialized types of personnel training, equipment, and engineering technology.

An accurate summary of the demand for tunneling, mining, and construction of underground cavities should contribute to the following specific benefits:

- Identifying research needs to maximize the returns from new technological developments.
- Planning construction schedules to avoid booms or busts and enable owners of projects to obtain more value for the dollars spent.
- Providing the equipment and materials industries with enough information to develop rational production schedules, employ their resources optimally, and sell products at favorable prices with higher profits.
- Helping contractors and service companies to make better long-range plans that will make their companies healthier and more competitive in the marketplace.
- Helping educators understand the industry's needs for future graduates.
- Enhancing the development of underground space through increased awareness of what is planned and of what could be done.

SCOPE OF THE PRESENT WORK

The data presented in this forecast were obtained by surveying key members of the underground construction and mining industries. In April 1980, the Subcommittee on Demand Forecasting sent letters to 150 planners, engineers, transit properties, water districts, government agencies, and individuals, requesting corrections and additions to the appended list of tunnel projects expected to go into construction between 1980 and 1990. A second series of letters was sent to 92 agencies known to be planning tunnel construction, requesting information in less detail on projects that might be started between 1980 and 2000. Additionally, the June (1980) issue of the *Tunneling Technology Newsletter*, which reported the Subcommittee's efforts, included a form for submitting information together with an invitation to the approximate 1,500 readers of the *Newsletter* to provide data concerning planned tunnel projects. Compilations of the information gathered by these means are presented in the following three chapters.

Specific Underground Construction Projects

Although many details of the projects are known, it must be emphasized that there are significant uncertainties in the forecast. Any construction project depends on funding, which in turn depends on such factors as the general economic environment, the urgency of the need, and the political priorities of the time. In using this data, the reader of Chapter 2 is safe in assuming that most of the works forecast will be built. The schedules are less reliable; the projects are likely to be initiated between 1980 and 2000, but their timing may differ significantly from the indicated schedule.

Nonspecific Construction Estimates

Chapter 3 contains projections of the amount of underground construction expected to occur in support of the nation's needs during the rest of the century. The projections are derived from a combination of known projects, together with nonspecific plans derived from needs in water supply, wastewater conveyance and treatment, transportation, hydropower, underground storage, defense, and oil mining. The projections are based on extrapolation of past trends in tunneling demand, of reasonable national goals, and use of existing technology.

Obviously, the range of uncertainty for this type of projection is larger than that of projections for specific underground construction projects. The reader should approach the nonspecific estimates with a degree of caution. The data on which these estimates are based are on file with the U.S. National Committee on Tunneling Technology.

Tunnel Demand for the Mineral Industry

Chapter 4 contains a projection of the lengths of shafts and tunnels anticipated by the U.S. mining industry. The projection has been divided into two categories: (1) metals and nonmetallic minerals, and (2) coal. They are based on an analysis of trends in the individual commodities, including demand, type of mining employed, and related factors. Trends appearing between the years 1966-1978 have been used as the basis for the best estimates of future output.

CHAPTER 2

SPECIFIC CONSTRUCTION PROJECTS

The information about specific, planned underground construction projects is arranged in Table 1 by states or other territorial designation. Each project is described by a few simple entries—namely—owner, designation or name, location, length, shape, area, general geological setting, and best estimate of the most likely date for starting construction. Where pertinent, further descriptive material is given in the footnotes.

The key to the abbreviations that appear under the heading "Shape" is as follows: B, box; C, circular, E, elliptical; H, horseshoe; R, rectangular; and Sp, special, which is explained in a footnote.

TABLE 1 Specific Construction Projects

		Tunnel Data					
Owner	Tunnel Designation	Location	Length (m)	Shape	Sect. Area (m^2)	Geology	Start Construction
U.S. Army Corps of Engineers	Power Tunnel	Bradley Lake Homer, Alaska	4,206	C	8.8	Argillite, graywacke	1985-86
	Tailrace Tunnel		1,585	C	18.7	Argillite, graywacke	1985-86
	Powerhouse		[a]	R	694.6	Argillite, graywacke	1985-86
	Power Tunnel	Mahoney Lake, Alaska	1,200	C	7.3	Phyllite (thin bedded)	1984
Kodiak Electric	Terror Lake	Terror Lake, Alaska	8,700	C	7.0	Quartz diorite	1983
Cities of Wrangel and Petersburg	Tyee Tunnel	Wrangel and Petersburg, Alaska	2,070	H	7.3	Quartzite gneiss	1981
	Tyee Powerhouse		[b]	R	450	Quartzite gneiss	1983
Ketchikan Public Utility	Swan Lake	Swan Lake, Alaska	670	C	8.8	Schist, dolomite, phyllite	1983
San Francisco Wastewater Management	Richmond Tunnel	San Francisco, California	3,060	C	7.2	Franciscan[c]	1981
	Westside[d]		4,590	C	16.5	Dune sand	1981
	Lake Merced		2,690	C	6	Sands	1981
	Outfall		5,510[e]	C	6	Sands (mostly)	1981
	Crosstown		10,400	C	14.5	Rock[c] (2/3), sands (1/3)	1983
	Channel-Islais[f]		2,360	C	7.2	Bay mud and sands, fills	1983

	Islais		?	?	?	Bay mud and sands, fills	1983
	Sunnydale		2,450	C	6	Rock, sands	1983 (or later)
	Yosemite		1,680	C	29.4	Rock, sands	1983 (or later)
	Yosemite-Sunnydale		2,690	C	29.4	Rock, sands	1983 (or later)
	North Shore Force Main		1,225	C	0.8	Fills, bay mud	1983 (or later)
	Hunters Point		1,835	C	7.2	Fills, mud, sand	1983 (or later)
	Mariposa		2,140	C	0.8	Fills, mud, sand	1983 (or later)
U.S. Army Corps of Engineers	Double Barrel[g]	Santa Ana River near Corona, California	427	C	46	Sedimentary siltstone and sandstone	?
	San Clemente Dam Tunnel (right abutment)	San Clemente, California	975	H	30	Good Sur Meta series (PAL) intruded by Santa Lucia granites (CRET)	1986
Pacific Gas and Electric Company	Kerekhoff 2	San Joaquin River, California	22,000	C	42	Rock	1981
	Butte	Paradise, California	350	B	3.3	Rock	1981
	Miocene (South Tunnel)		1,200	B	4.5	Rock	1981
	Miocene (North Tunnel)		230	B	3.3	Rock	1981

---

[a] Dimensions (m) are 45.7 × 15.2 × 45.7.
[b] Dimensions (m) are 30 × 15 × 30.
[c] Rock is poor in areas (mixed rock and melange).
[d] Under the Great Highway.
[e] Possibly 1,500 m with a slurry mole.
[f] Mined in rock, or cut and cover in rock, depending on location choice.
[g] Modification of the Prado Dam.

		Tunnel Data					
Owner	Tunnel Designation	Location	Length (m)	Shape	Sect. Area (m^2)	Geology	Start Construction
Pacific Gas and Electric *(continued)*	Kerekhoff 2 (Powerhouse)	Fresno, California	110	C	525	Rock	1981
Southern California Edison Company	Balsam Meadow Hydroelectric Project	Shaver Lake, California (Sierra Nevada Mountains)	5,030	H	31.2	Rock	1982
	Balsam Meadow Hydroelectric Powerhouse		[a]	H	600	Rock	1983
Metropolitan Water District of Southern California	Foothill Feeder[b]	Los Angeles County, California	55,000	C	28	Rock (35,000 m), soft sandstone (20,000 m)	1990
Monterey City Flood Control District	San Antonio Power Plant Project	San Antonio and Nacimento Rivers, California	3,300	C	10.6	Rock	1985
Calavaras County Irrigation District	Stanis Laus	Calavaras County, California	15,500	H	16.5	Granite	1982
Kings River Conservation District	Dinkey Creek	Kings River District, California	24,100	C	6	Granite	1981
El Dorado Irrigation District	Sofar Upper Mountain	El Dorado District, California	16,500 14,200	C H	6 13.7	Granite	1984
Southern California Rapid Transit District	Metro Wilshire Corridor	Los Angeles, California	60,000	C	25	Sedimentary rock	1984-90
Colorado Division of Highways	Glenwood Canyon Tunnels[c]	I-70, Glenwood Canyon, Colorado	2,000[d]	H	75	Sedimentary and cambrian rocks	1982

Denver Water Board	Eagle-Colorado Water Tunnels[e]	Western Colorado	75,000	C	7 to 11	Sedimentary rock and granite	1985
Northern County Water District	Greer Canyon	Longmont, Colorado	4,890	?	28	Sedimentary rock and granite	1985
U.S. Army Corps of Engineers	Rippowan Diversion	Stamford, Connecticut	2,987	C	49.3	Gneiss, schist	?
Washington Metropolitan Area Transit Authority	B-9 Line	Washington, D.C.	100	B	52.1	Soil	1980
			800	H	22.7	Mixed face	1980
			2,400	C	25.4	Rock	1980
	B-9 Station[f]		400	C	92	Rock	1980
	B-10a Line		4,800	C	25.4	Rock	1981
	B-10b Station[f]		400	C	92	Rock	1982
	B-11a Line		4,700	C	25.4	Rock	1982
			500	B	28.1	Soil	1982
	B-11b Line		300	B	28.1 to 130 (varies)	Soil	1983
	B-11 Station[g]		300	B	210	Soil	1983
	E-1a Line		1,400	C	26.8	Soil	1982
			500	B	130	Soil	1982
	E-1a Station[g]		300	B	210	Soil	1982
	E-1b Line		500	C	26.8	Soil	1984
	E-1b Station[g]		300	B	210	Soil	1984

[a] Dimensions (m) are 40 × 15 × 40.
[b] Tentative plans only.
[c] Five two-lane highway tunnels.
[d] Length is the total for five tunnels.
[e] Denver water-supply project schedule indefinite.
[f] Dual chamber station.
[g] Arch station.

		Tunnel Data					
Owner	Tunnel Designation	Location	Length (m)	Shape	Sect. Area (m^2)	Geology	Start Construction
Washington Metropolitan Area Transit Authority *(continued)*	**E-2 Line**	**Washington, D.C.**	600	B	28.1	Soil	1984
			1,700	C	26.8	Soil	1984
	E-2 Station[a]		300	B	210	Soil	1984
	E-3 Line		100	B	130	Soil	1984
			2,200	C	26.8	Soil	1984
	E-3 Station[a]		300	B	210	Soil	1984
	E-4 Line		5,100	C	26.8	Soil	1984
	E-4 Station[a]		300	B	210	Soil	1984
	E-5 Line		1,000	B	52.1	Soil	1985
	E-6 Line		1,100	B	52.1	Soil	1985
			2,400	C	26.8	Soil	1985
	F-3 Line		100	B	130	Soil	1981
			2,300	C	26.8	Soil	1981
	F-3 Station[a]		300	B	210	Soil	1981
	F-4 Line		300	B	52.1	Soil	1981
			200[b]	B	28.1	Soil	1981
			400	B	52.1	Soil	1981
	F-5 Line		1,100	B	28.1	Soil	1981
			400	B	52.1	Soil	1981
	F-5 Station[c]		300	B	140	Soil	1981
	F-6 Line		500	B	52.1	Soil	1982
	F-7 Line		100	B	52.1	Soil	1983

Washington Metropolitan Area Transit Authority *(continued)*	F-8 Line	Washington, D.C.	600	B	52.1	Soil	1983
			300	B	28.1	Soil	1983
Government of the District of Columbia	Crosstown Water Main	Washington, D.C.	4,000	C	6	Rock	1981-83
Georgia Power Company	Rocky Mountain Power Plant	Rome, Georgia	900	C	29.2	Rock	1981
			900	C	65.7	Rock	1981
Metropolitan Atlanta Rapid Transit Authority	Brookwood	Atlanta, Georgia	1,800	H	31.5	Rock	1982
City and County of Honolulu	Harts Waialae Subway[d]	Honolulu, Hawaii	1,000	B & C	25 (each of 2 tunnels)	Volcanic rock	1990
Hawaii Department of Transportation	Route H-3, Trans Koolau Tunnel[e]	Oahu, Hawaii	2,000	H	150 gross (each of 2 tunnels); 110 net (each)	Volcanic rock	1985
Honolulu Department of Transportation	Harts Honolulu Area Rapid Transit System	Honolulu, Hawaii	3,000	C	20	Coral sand	1990
Department of Public Works, City and County of Honolulu	Sewer Tunnel Relief Program	Honolulu, Hawaii	1,130	C	2.5	Volcanic rock	1980-85
			3,000	C	2.5	Volcanic rock	1985-90
U.S. Army Corps of Engineers[f]	Lucky Peak Project	Boise, Idaho	320	C	32.1	Basalt	1984-85
Idaho Power	North Fork Payette	Smith's Ferry, Idaho	26,642	C	18.8	Rock	1985

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[a] Arch station.
[b] Sunken tube or cut and cover.
[c] Low box station.
[d] One-third cut and cover; two-thirds twin, single-track mined tunnels.
[e] Highway tunnel, presently planned for twin three-lane bores.
[f] Application for the project by the Boise Project Board of Control.

Owner	Tunnel Designation	Tunnel Data					
		Location	Length (m)	Shape	Sect. Area (m^2)	Geology	Start Construction
Commonwealth Edison Company	Northwest Illinois 300 MW Underground Pumped Storage	Northwest Illinois	15,240	H	557.0	?	1987
Metropolitan Sanitary District of Greater Chicago	Tunnel and Reservoir Plan (TARP), North Branch, Phase I	Chicago, Illinois	6,000	C	29.2	Limestone, shale	1981-85[a]
			9,000	C	65.7	Limestone, shale	1981-85[a]
	TARP, Phase II[b]		121,000	C & R	7.4 to 90 (varies)	Sand, gravel, dolomitic limestone	1990
City of Chicago	Franklin Street Subway	Chicago, Illinois	5,500	C	23.7	Soft ground	1990
	Subway Extension		9,200	C	23.7	Soft ground	1985
	Crosstown Expressway Water Tunnels		7,600	C	7.3	Rock	1981
	City Sewer System		15,600	C	3.6 to 32 (varies)	Rock (83%), earth (17%)	1985
			2,800	C	3.6 to 32 (varies)	Rock, earth	1990
U.S. Park Service	Cumberland Gap	Middleboro, Kentucky	2,500	C	65.7	Rock	1982
Interstate Division for Baltimore City, Maryland Department of Transportation	I-95, Ft. McHenry Tunnel[c]	Baltimore, Maryland	2,180[d]	—	—	—	1980-85[a]
	I-83, Fells Point Tunnel[e]		1,500	E or R[f]	180 gross (each of 2 tunnels); 100 net (each)	Sand, clay	1983

Mass Transit Administration, Baltimore, Maryland	South Line	Baltimore, Maryland	16,000	C	23.7	Soil	1990
	System Extensions		22,000	C	23.7	Soil, rock	1995 (or later)
Massachusetts Bay Transportation Authority	?	Harvard to Alewife, Massachusetts	6,000	?	23.7	?	1983
	?	South Cove Section of S.W. Corridor	200	?	23.7	?	1980
	Arlington Heights	Alewife, Massachusetts	5,000	?	23.7	?	1990 (or later)
	Route 128	Arlington Heights, Massachusetts	6,000	?	23.7	?	1990 (or later)
	Charles Connector	Bowdoin, Massachusetts	500	?	23.7	?	1990 (or later)
	Green Line Relocation	North Station	300	?	23.7	?	1990 (or later)
	South Station Connector	North Station—South Station	2,000	?	23.7	?	1990 (or later)
	North Shore Transportation Improvement	?	400	?	23.7	?	1990 (or later)
U.S. Army Corps of Engineers	Monoosnoc Brook Diversion[g]	Leominster, Massachusetts	975	C	10.5	Phyllite	—
	Planc By-Pass Tunnel[h]	Fitchburg, Massachusetts	5,486	C	35.3	Granite	—
City of Northfield	Water Supply	Northfield, Massachusetts	16,000	C	7	Rock	1990

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[a] Continuous construction.
[b] Subject to U.S. Army Corps of Engineers' study.
[c] A description of the project is given by Pollak (1981).
[d] Includes 1,270 m of immersed tubes and 910 m of approach tunnels.
[e] Immersed tube, six-lane highway.
[f] Alternate designs: elliptical steel shell or rectangular concrete box.
[g] Study, Stage 3.
[h] Study, Stage 1.

		Tunnel Data					
Owner	Tunnel Designation	Location	Length (m)	Shape	Sect. Area (m^2)	Geology	Start Construction
Boston Metropolitan District Commission	Tunnel Loop Water Supply	Boston, Massachusetts	16,000	C	7	Rock	1990
	Deep Rock Tunnel Plan		27,000	C	80	Rock	1990
City of Townbrook	Flood Control	Townbrook, Massachusetts	3,200	C	20	Rock	1985
Southeast Michigan Transit Authority	Woodward Avenue Rapid Transit	Detroit, Michigan	7,270	C	23.7	Soil	1984
U.S. Army Corps of Engineers	Bassett Creek	Minneapolis, Minnesota	245	C	4.7	Alluvium	1984
Northern Lights	Kootenai Falls Hydro Project	Lincoln City near Troy, Montana	610	C	58	Quartzite, limestone, dolomite	1981-82
U.S. Army Corps of Engineers	Passaic River	Passaic River, New Jersey	18,000	H & C	90 to 200 (range)	Sandstone, shale, basalt	1990
Merrill Creek Project Owners	Merrill Creek	Harmony Township, New Jersey	3,000	C	8.5	Rock	1982
Water Resource	Oakwood Beach	New York, New York	11,600	C	5	Soft ground	1983
Pure Waters	Culver-Goodman	Rochester, New York	9,480	C	19	Rock	1979 (September)
New York State Department of Transportation	Westway Tunnel	New York, New York	4,500	B	480 gross; 265 net	Fill, rubbish	1990
Federal New York City	N.E.W.S.	New York, New York	97,000	C	23.7	Sedimentary, metamorphic, igneous	1990

New York City	City Water Tunnel #3	New York, New York	21,000	C	19 to 42	Sedimentary, metamorphic, igneous	1982[a]
U.S. Army Corps of Engineers	Molly Ann's Brook[b]	New York	1,600	C	7.4 to 30	Sedimentary, metamorphic, igneous	1987
	Mamaroneck	New York	565	C	970	Metamorphic	1990's
New York City Transit Authority	131-A, East 63rd (remodified)	New York, New York	5,330	H & C	58	Rock	1985
	131-B, Super Express (remodified)		2,100	H & C	58	Rock	1995
	131-D	Southeast Queens, New York	3,070	H & C	58	Rock	1985
	132-A, 2nd Avenue Line	New York, New York	7,600	H & C	58	Rock	1990
	132-B, 2nd Avenue-Bronx		1,780	H & C	58	Rock	1995
	132-C, 2nd Avenue Line		5,800	H & C	58	Rock	1995
	133, Jamaica "E-1" Connection		800	H & C	58	Rock	1985
	Planned Future Construction		20,300	H & C	58	Rock	1998
Niagara Frontier Transportation Authority	Delavan Station	Buffalo, New York	185	E	57	Limestone	1981
	Humboldt Station		185	E	57	Limestone	1981
	La Salle Station		185	E	57	Limestone	1981
	South Campus Station		185	E	57	Limestone	1981
	Storage Track		100	C	25	Limestone	1981

[a] Restart; original start in early 1970's.
[b] Planning stage.

		Tunnel Data					
Owner	Tunnel Designation	Location	Length (m)	Shape	Sect. Area (m^2)	Geology	Start Construction
Niagara Frontier Transportation Authority *(continued)*	North Tail Track	Buffalo, New York	100	C	25	Limestone	1981
Power Authority of New York	Prattsville Pumped Storage	New York	1,303	C	77	Rock	1983
Consolidated Edison	Corwall	New York	549	C	116.8	Rock	?
New York City Department of Water Resources	Interceptor Sewer	New York, New York	11,600	C	4.7	Soft ground	1983
U.S. Army Corps of Engineers	Pumped Storage (power)	Lake Sakakawea, North Dakota	1,825	C	49.3	Ft. Union group	1990-95
	Burlington Dam[a]	Minot, North Dakota	2,380	C	29	Tongue River formation	1984
Regional Sewer District	Southwest	Cleveland, Ohio	24,400	C	7.3	Rock	1982
U.S. Army Corps of Engineers	?	Freedom, Oklahoma	4,900	C	14.3	Rock	1982
	?		3,700	C	57.3	Rock	1981
U.S. Army Corps of Engineers	Elk Creek Project	Rogue River, Oregon	183	R	10.7	Basalt, tuff, breccia	1985[b] (or later)
	Bonneville Project	Columbia River, Oregon	93	R	10.7 (each of 3 tunnels)	Overburden	1985[b] (possible)
	Dalles Project	Dalles, Oregon	31	C	7.3	Basalt	1982
Allegheny County Port Authority	Mt. Lebanon Tunnel[c]	Pittsburgh, Pennsylvania	920	H	25 (each of 2 tunnels)	Limestone, shale	1983
	Pittsburgh LRT, Downtown Subway[d]		1,500	B	25	Sand, clay, shale	1983

U.S. Army Corps of Engineers and Allegheny Electric	Raystown Dam[e]	Pennsylvania	1,000	?	18	Sedimentary	1990
U.S. Army Corps of Engineers	Tamaqua	Pennsylvania	800	C	7	Sandstone, shale	1985
U.S. Army Corps of Engineers	Big River Aqueduct[f]	Warwick, Rhode Island	10,700	C	3.6	Granite, gneiss	—
Duke Power	Bad Creek Pumped Storage	South Carolina	1,440	C	61.3	Rock	1985
U.S. Army Corps of Engineers	Pumped Storage (power)	Lake Francis Case, South Dakota	3,050	C	49.3	Chalk, Pierre shale	1985-86
	Pumped Storage (power)	Lake Sharpe, South Dakota	2,450	C	49.3	Pierre shale	1990
U.S. Department of Energy	Strategic Petroleum Reserve	Texas and Louisiana	—	Sp[g]	—	Salt domes	1980
Water and Power Resources Service	Hades	Duchesne, Utah	6,751	C	5 to 9	Rock	1981
	Rhodes		1,252	C	23.7	Rock	1981
	Stillwater Tunnel		7,600	C	16.4	Rock	1982[h]
U.S. National Park Service	Cumberland Gap[i]	Cumberland Gap, Virginia	1,200	H	70 (each of 2 tunnels)	Shale	1984
Virginia Department of Transportation	Craney Island Tunnel	Craney Island, Virginia	1,460	H	70	Sand, silt	1985
	Second Elizabeth	Norfolk, Virginia	1,020	H	70	Sand, silt	1985

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[a] Progress (Phase II DM) has been suspended due to funding problems.

[b] No schedule is currently available on construction start.

[c] Twin, single-track transit.

[d] Cut-and-cover box sections; one- and two-track transit.

[e] Feasibility studies.

[f] Study, Stage 3.

[g] Solution-mined caverns up to 90 m in diameter and 600 m in height. The total volume is approximately 50 million m^3.

[h] Construction has been suspended and a new contract for completion of the tunnel and its portal structures is expected to be awarded late in 1981. Additional details are given by Marushack and Tilp (1980).

[i] Twin, two-lane highway tunnels.

		Tunnel Data					
Owner	Tunnel Designation	Location	Length (m)	Shape	Sect. Area (m^2)	Geology	Start Construction
Washington State Department of Transportation	Mt. Baker Ridge Tunnel	Seattle, Washington	640	C	265	Consolidated clay, sand	1984
	Mercer Island Tunnel	Washington	920	C	400	Consolidated clay, sand	1987
U.S. Army Corps of Engineers	Power Tunnel[a]	Wynoochee, Washington	108	C	29.2	Basalt	1988
	Draft Tunnel[a]		108	C	29.2	Basalt	1988
U.S. Department of Energy	Nuclear Waste Repository in Basalt	Hanford, Washington	—	Sp[b]	Varies	Basalt	1989
Snohomish City Public Utility Department #1	Sulton River Project	Everett, Washington	12,900	C	11	Greywacke	1981
Milwaukee Metrolitan Sanitary District	"TARP"	Milwaukee, Wisconsin	15,200	C	7.3	Soil	1990
Territory of Guam	Outlet Works[c]	Ugum River Dam, Guam	290	C	4.67	Fine-grained saprolitic agglomerate grading into residual tuff	Not authorized
Commonwealth of Puerto Rico	Cerillos Dam Diversion and Water Regulating Tunnels[d]	Ponce, Puerto Rico	426	C	23.6	Limestone, metavolcanics (steeply dipping)	1982

[a] Feasibility study in progress.

[b] Galleries at depths of 600 to 900 m. The total volume is approximately 10 million m^3.

[c] The project is in the study report stage. The outlet tunnel is located beneath the right abutment. At dam centerline the tunnel is 36 m below the ground surface.

[d] The diversion tunnel and the regulating tunnel join. Flow into the regulating tunnel will be passed into the diversion tunnel and discharged downstream.

CHAPTER 3

NONSPECIFIC CONSTRUCTION ESTIMATES

WATER SUPPLY

The summary in Table 2 of projected tunneling needs for the nation's water supply is based on information obtained from specific underground construction projects listed in Chapter 2, combined with data furnished by the Water and Power Resources Service of the U.S. Department of the Interior. Because the summary does not include detailed data from all potential owners, the totals given are believed to be conservative.

TABLE 2 Water Supply Construction Estimates

	Projected Length of Tunnels (km)	
Time Period	Under 10 m^2 in cross section	Over 10 m^2 in cross section
1980-1985	100	100
1985-1990	50	50
1990-1995	40	80
1995-2000	10	20

WASTEWATER CONVEYANCE AND TREATMENT

The projections in Table 3 are based on the Subcommittee's review of the U.S. Environmental Protection Agency (EPA) document, *1978 Needs Survey, Conveyance and Treatment of Municipal Wastewater*. Although discussions with EPA representatives substantiated both the need and the time frame, the final projections are the sole responsibility of the Subcommittee.

TABLE 3 Construction Estimates for Collector and Interceptor Sewers Greater than 3 m^2 in Cross Section

Time Period	Projected Length of Tunnels (km)
1980-1985	50
1985-1990	100
1990-1995	150
1995-2000	100

STORM, SANITARY, AND STORAGE TUNNELS

The projections in Table 4 are based on information provided by the municipalities involved. All of the projected tunnels are in the planning, design, or early implementation stages.

TABLE 4 Storm, Sanitary, and Storage Tunnels Ranging from 7 m^2 to 113 m^2 in Cross Section (Chicago, Milwaukee, and San Francisco)

City	Time Period	Projected Length of Tunnels (km)
Chicago	1980-1990	100
Milwaukee	1980-1990	17
San Francisco	1980-1990	40

UNDERGROUND STORAGE FOR SANITARY SEWER SYSTEMS

Engineering studies have shown that the addition of underground storage capacity upstream of sewage-treatment plants would equalize flow rates through the plants, improve their efficiency, and reduce the cost of sewage treatment. If this approach were applied to the nation's projected additional sewage-treatment needs in the period from 1980 to 2000, the result would be a requirement for 25 million m^3 of underground space built in a variety of sizes to match treatment plant requirements.

TRANSPORTATION

The highway tunnel projections in Table 5 are based on information furnished by the Federal Highway Administration. Where data were incomplete, the Subcommittee made its own estimates.

TABLE 5 Highway Tunnels

Time Period	Estimated Total Length (km)
1980-1990	18
1990-2000	18

The rail tunnel projections in Table 6 are based on data obtained from the Urban Mass Transportation Administration and a number of the municipalities involved. The timing estimates are based partly on furnished data and partly on the judgment of the Subcommittee.

TABLE 6 Rail Transit Tunnels

Time Period	Estimated Total Length (km)
1980-1985	30
1985-1990	100
1990-1995	50
1995-2000	90

HYDROELECTRIC POWER, INCLUDING PUMPED STORAGE

The projections in Table 7 are based on data from specific underground construction projects, combined with information from the Water and Power Resources Service and the Federal Energy Regulatory Commission on the number of plants to be built. To convert the information into projected tunnels, the Subcommittee developed data for a typical plant, based on a profile from specific underground construction projects. Approximately 25 percent of the pumped-storage plants are assumed to use underground storage.

TABLE 7 Estimated Tunneling for Hydroelectric Power

	Projected Length of Tunnels (km)		
Time Period	Under 25 m^2 in cross section	25-100 m^2 in cross section	500 m^2 in cross section
1980-1985	75	35	15
1985-1990	45	10	30
1990-1995	15	10	15
1995-2000	15	10	15

UNDERGROUND STORAGE

Strategic Petroleum Reserve

The U.S. Department of Energy estimates that large mined caverns with a combined volume of 50 million m^3 will be built between 1980 and 1990 to serve the needs of the Strategic Petroleum Reserve.

Nuclear-Waste Disposal

Several disposal areas are to be selected and developed between 1985 and 2000, under U.S. Department of Energy sponsorship. The combined volume of these areas is expected to be 30 million m^3.

Defense

The demand for defense-related underground construction will be affected significantly by decisions made in the early 1980's. It could be for as much as 20 million m^3 for missile sites and underground command posts, most of which would be constructed between 1985 and 1995. These projects do not include the civil construction routinely carried out by the Corps of Engineers.

Oil Mining

Mining to recover oil from fields depleted by conventional pumping can be accomplished by tunneling beneath the fields and draining oil from the formation by gravity combined with vertical water flooding. This is estimated to increase domestic recoverable reserves by 100 billion barrels, nearly as much as has been removed since production began about 125 years ago. Preliminary analyses show that the cost of oil obtained by this tertiary method would be competitive with present OPEC prices.

Recovery of this oil would require underground excavation of tunnels and shafts with total volumes of the order of 1 billion m^3. The Subcommittee considers this a highly likely future development, although the amount of excavation occurring in the period 1980-2000 cannot be accurately predicted at this time.

CHAPTER 4

TUNNEL DEMAND FORECASTING FOR THE MINERAL INDUSTRY

Metals, nonmetallic minerals, and coal are best treated as three separate groups, according to their manners of occurrence and methods of extraction. For the purpose of this aggregation, a tunnel is defined as a horizontal, vertical, or inclined underground opening with a cross-sectional area of 2 m^2 or more.

Several sets of U.S. Bureau of Mines (USBM) information are used in making the forecast. They include data found in the *Minerals Yearbook* (1965-1978) on underground openings driven, USBM statistics on tons of ore and waste produced in open-pit and underground operations, the 1975 *Mineral Facts and Problems* forecasts of demand by commodity, and USBM Minerals Availability System information on identified domestic deposits.

The first step in making a forecast is to tabulate data for each commodity, over a period of 10 or more years, with regard to shaft and winze sinking, raising and drifting, cross-cutting, and tunneling. The tabular format includes columns giving short tons of production per linear foot for each activity by commodity. Provision for entering totals should also be made. The result should provide data on the annual averages of total footage driven, the corresponding short tons of production, and a factor for short tons per foot.

The next step is to tabulate the production of each commodity in tons, ounces, or pounds for a period of 10 years or more. The information is entered on graph paper to facilitate projection. The total footage for each commodity is plotted on the production graph. Also plotted on the production graph is a separate curve showing the amount of the commodity derived from underground operations.

The next step is to forecast the identified deposits that can be expected to go into production in the future. This effort should combine the best information available to commodity specialists (based on USBM Minerals Availability System data) to evaluate which deposits may be placed in production in the future in terms of which deposits will be mined by underground methods and their aggregate production. The method of mining and the grades of the specific deposits are considered in projecting the footage forecasts.

METALS AND NONMETALLIC MINERALS

The data for metal and nonmetal mining are derived for each of the principal mined commodities from producer-reported figures on shafts, raises and drifting, and so on. The footages are related to tons of ore of the commodity produced to arrive at a value for short tons per foot.

This factor is related to the production forecasts for each commodity according to the proportion that would be mined underground. Charting the data reflects the expected trend in underground openings or tunnels for each commodity. Although the mining industry has traditionally used English units of measurement, as indicated above, the forecasts that follow in Tables 8 and 9 are listed in metric units for consistency with the remainder of this report.

TABLE 8 Tunnels in Metal Production

	12-Year Average, 1966-1978		Forecast Length of Tunnels (km)[b]		
Mineral	Metric tons[a] (thousands)	km	1980	1985	1990
Copper	1,565	60	57	53	50
Gold	165	23	23	20	17
Iron ore	857	32	27	22	18
Lead	961	32	32	32	32
Mercury	11	2	2	2	2
Silver	187	13	12	10	8
Tungsten	103	5	5	3	3
Uranium	1,224	110	113	117	120
Zinc	952	37	37	37	37
All other metals	567	25	27	28	30
Totals		339	335	324	317

[a] In some instances the basis is metric tons of ore; in others it is metric tons of metal.

[b] Based on demand forecasts from *Mineral Facts and Problems* (1975).

TABLE 9 Tunnels in Nonmetallic Mineral Production

	12-Year Average, 1966-1978		Forecast Length of Tunnels (km)[a]		
Mineral	Metric tons (thousands)	km	1980	1985	1990
Barite	8.3	0.8	0.8	0.8	0.7
Fluorspar	59.2	4.0	4.0	4.0	4.0
Gypsum	36.6	1.5	1.5	1.5	1.5
Phosphate rock	27.8	1.3	1.3	1.3	1.3
Talc, steatite, and pyrophyllite	24.6	2.2	2.2	1.8	1.7
All other nonmetallic minerals	1,824.2	55.0	55.0	55.8	56.7
Totals		64.8	64.8	65.2	65.9

[a] Based on demand forecasts from *Mineral Facts and Problems* (1975).

COAL

The forecasts in Table 10 for tunnels in coal mining are based on assumptions concerning the average coal bed thickness, average entry width, and average specific weight of coal. Additionally, the following assumptions are used:

- Conventional mining sections obtain 80 percent* of production from tunneling.
- Continuous mining sections obtain 90 percent* of production from tunneling.
- Other mining sections obtain 75 percent* of production from tunneling.
- No longwall production is attributed to tunneling, because development work is done by conventional or continuous equipment.

Coal production per kilometer of tunnel is calculated to be 10,500 metric tons. The estimates of coal supply for 1985 and 1990 are from the Federal Energy Administration (1974) report, *Project Independence*. Those for the year 2000 are from the USBM report (Dupree and Corsentino, 1975), *U.S. Energy Through the Year 2000* (revised).

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*The remaining 20-10-25 percent of production comes from slabbing and other means that do not fit the definition of tunneling.

TABLE 10 Underground Coal Production, by Method of Mining

Method of Mining	1970	1980[a]	1985[a]	1990[a]	2000[a]
	Production by Year (thousands of metric tons)				
Underground Production					
Conventional	137,614	156,000	121,000	128,000	151,000
Continuous	154,452	177,000	254,000	288,000	362,000
Longwall	6,484	7,000	42,000	57,000	91,000
Other	9,440	14,000	—	—	—
Total	307,990	354,000	417,000	473,000	604,000
Underground Production from Tunneling					
Conventional (80 percent recovery)	110,091	125,000	97,000	102,000	121,000
Continuous (90 percent recovery)	139,006	160,000	229,000	260,000	326,000
Longwall (none)	—	—	—	—	—
Other (75 percent recovery)	7,080	10,000	—	—	—
Total	256,177	295,000	326,000	362,000	447,000
Kilometers of Tunneling	24,000	27,500	30,500	33,800	41,700

[a] Estimated

SUMMARY FORECAST

The tunnel demand for the mineral industry forecast in Table 11 is a summary developed from the data presented in this chapter for metals (Table 8), nonmetals (Table 9), and coal (Table 10).

TABLE 11 Summary Forecast of Tunnel Demand in Coal, Metal, and Nonmetallic Mineral Mines

	Projected Tunnel Demand (km)			
Commodities	1980	1985	1990	2000
Coal	27,500	30,500	33,800	41,700
Metal	335	324	317	310[a]
Nonmetal	65	65	65	65[a]
Totals (rounded)	27,900	30,900	34,180	42,075

[a] Projected from 1985 and 1990.

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