



REPORT
OF THE
MONTREAL TRANSPORTATION COMMISSION
FOR THE ESTABLISHMENT OF A
SYSTEM OF RAPID MASS TRANSPORTATION

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COMMISSIONERS

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RICHARD F. QUINN, Vice-Chairman

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LÉONARD LÉGER, N.P.

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MONTREAL TRANSPORTATION COMMISSION

159 Craig Street, West

*The Chairman and Members
of the Executive Committee
of the City of Montreal,
City Hall,
Montreal.*

Gentlemen:

The Montreal Transportation Commission has the honour to submit to you its report and plans for the establishment of a system of rapid mass transportation for Montreal and its metropolitan district. The Commission has prepared this report and these plans following a request of the City of Montreal expressed in its By-law No. 1981, and with a view to studying all the possibilities of providing Greater Montreal with the best possible system of transportation.

The recommendations of the Commission include, in the first place, the construction of an initial subway of a length of about seven and three-quarter miles, with provision for a system of autobus and trolley bus routes functioning in conjunction with this initial subway, in such a manner that the greatest possible number of people in the metropolitan region would benefit from this system of rapid mass transportation from the commencement of its operation.

In this report you will also find a detailed estimate of the cost of the initial subway and the method of financing that we suggest.

We have reached the conclusion that the users of the mass transportation system could not alone absorb the considerable capital cost which the construction of a subway would entail. As stated in the report, this cost, excluding that of the fixed equipment required for its operation as a transit facility and of the subway cars, should be assumed by the general public. It will therefore be incumbent on competent authorities to decide when, from the point of view of the financial problems involved, it is feasible to execute the project.

We produce at the same time, ~~bound in a separate volume~~, general plans of this initial subway. These general plans are accurate ~~and final, but have not been~~ prepared in the detail required for the award of contracts. They do ~~provide, however, the basis for the~~ completion of contract plans and specifications, should it be decided to ~~execute this project.~~

We believe that the initial subway which we have just referred to is absolutely necessary to mass transportation in the metropolitan district. Moreover, keeping in mind future needs, we have also made studies for the establishment of an overall rapid transit system. This system would include twenty-three miles of subway operated in conjunction with autobus and trolley bus routes. It is evident that it would be necessary to proceed with this overall plan in stages, each new part of the subway to be coordinated with the preceding sections built.

In view of the high cost of carrying out extensive studies and the preparation of final general plans and the estimate of the cost of the work, the Commission has considered that it would be premature at this stage to prepare plans covering the different sections completing the overall

subway system, but limited itself to the proposed initial subway. Nevertheless, these studies indicate that the different sections to be included in the overall subway system would not present serious construction problems.

The progressive execution of this overall plan will depend on numerous factors of which the principal ones will be the trends in the population growth, traffic conditions and the financial situation.

When the Commission took possession of the undertaking of the Tramways Company on June 16, 1951, it immediately made plans to set up an organization to prepare this report. A special department composed of personnel in the employ of and under the control of the Commission, has worked on the preparation of plans and the elaboration of this report; the officers of the other departments of the Commission have also lent their valuable assistance. The work commenced on August 1, 1951, and terminated during the month of June 1953.

Work of this kind is of a very specialized character, and systems of underground rapid mass transportation exist only in some large cities of the world. It was necessary, in order to direct our studies, to retain the services of an engineer of the highest competence and of wide experience in this kind of undertaking. On July 19, 1951, the Commission retained the services of Mr. Charles E. De Leuw, President of De Leuw, Cather & Co., Chicago. Mr. De Leuw is recognized as an authority in this work; he has prepared reports on rapid mass transportation system for several large cities, amongst others, Chicago, Los Angeles, San Francisco, Detroit, Cleveland, Washington and Toronto. He acted as Chief Engineer for the construction of the Chicago Subway from 1941 to 1944; he has also directed the preparation of the plans for the Toronto Subway and is presently supervising its construction. He is carrying out the same duties in connection with the rapid transit project now in the course of construction at Cleveland, Ohio.

The Commission desires to express its thanks for the efficient collaboration which it has received from the officials of the City of Montreal, the municipalities of the metropolitan district, and the public utilities and railway companies. The Commission also wishes to thank all those who have been good enough to supply information which it has found highly useful.

All the Commissioners have approved this report, with the exception of Mr. Jean Constantin who has dissented as to the opportunity of building a subway.

Respectfully submitted,

A. DUPERRON,
Chairman and General Manager,

RICHARD F. QUINN,
Vice-Chairman,

LÉONARD LÉGER,

C. A. SYLVESTRE,
Commissioners.

MONTREAL, SEPTEMBER 15, 1953.

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CHAPTER 1

MONTREAL

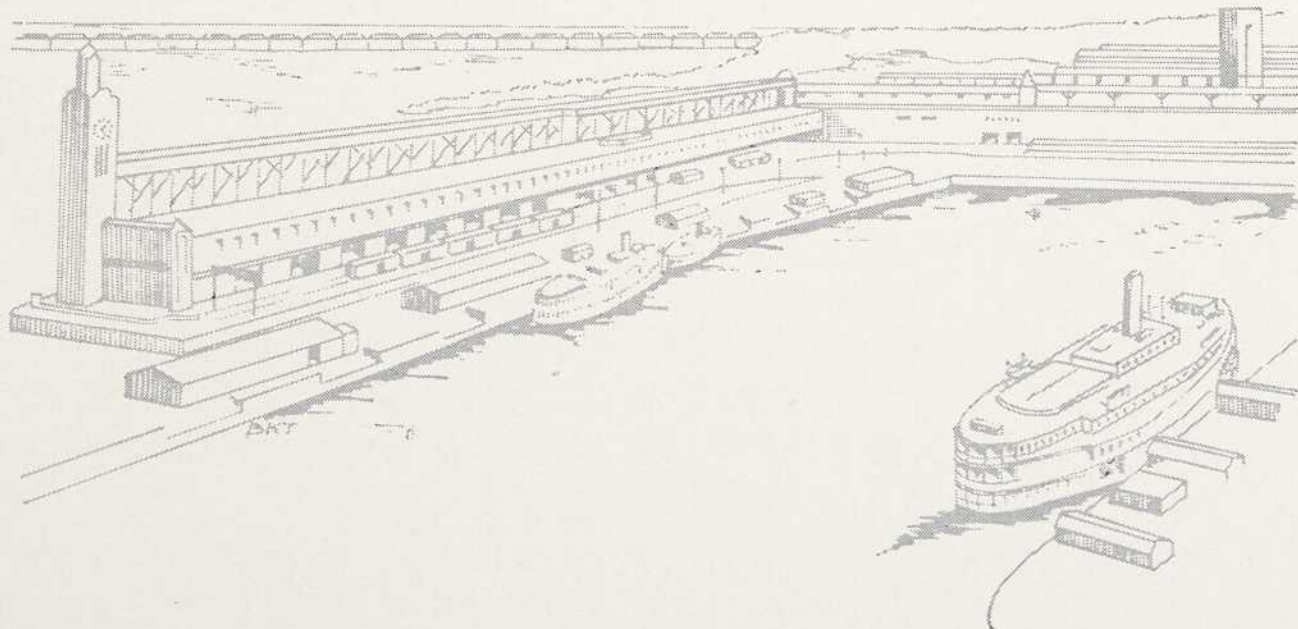
METROPOLIS OF CANADA

The founders of Montreal showed remarkable foresight when they chose this location to establish a colony. Even if they could not visualize the tremendous progress of the next three centuries, they nevertheless must have felt that such a natural crossroads was destined for a great future. We can bear witness today that they made no error, as Montreal is now the metropolis of Canada.

Because of the St. Lawrence River, Montreal will always constitute a junction between the Atlantic and the Middle West by way of the Great Lakes. A tributary, the Richelieu River, links our city with New York, while the Ottawa River provides a direct connection with the Nation's Capital. A network of canals allows uninterrupted navigation. Montreal Harbour, the world's greatest inland seaport, is open to navigation from approximately the middle of April to the end of November. It is well equipped and can accommodate most ocean vessels. Piers can berth 105 ships in a harbour area of 10 square miles. Facilities include 2,179,000 square feet of transit freight sheds, 4 grain elevators with a total capacity of over 15 million bushels, a large cold storage warehouse, a fleet of tugs, dredges, derricks and scows, and a 61 mile harbour railroad.

The two principal Canadian railways have their headquarters in Montreal. The Canadian National Railways, employing 24,000 persons and operating 529 miles of track in the Montreal area. The Canadian Pacific Railway, with 17,000 employees and operating 485 miles of track in and around Montreal. Extensive yards and shops are maintained by both railways in the Montreal metropolitan region.

Montreal is an aviation centre of international importance. Its airport located at Dorval has all the facilities essential to air travel. It is served by Trans-Canada Airlines, Canadian Pacific Airlines,



British Overseas Airways Corporation, Colonial Airlines, Royal Dutch Airlines, Air-France, and others.

Industrial expansion in the Montreal region has been phenomenal. According to 1949 statistics there were, in Montreal, 4,554 manufacturing establishments employing 219,236 persons. Salaries and wages totalled \$481,568,343. The cost of raw materials was \$1,125,411,070 and the gross value of products was \$2,079,892,373. These figures show clearly the industrial activity which is increasing year by year. There is every indication that industrial progress will continue at an even greater rate during the next half century and that Montreal will maintain its position among the leading cities of North America.

On the cultural and educational side, Montreal's position is no less outstanding. The metropolitan region is proud of its two universities, Université de Montréal and McGill University, which are internationally famous, and of its numerous institutions for secondary learning, schools for special studies, and its 444 primary schools. These are precious assets in the moulding of tomorrow's citizens.

POPULATION

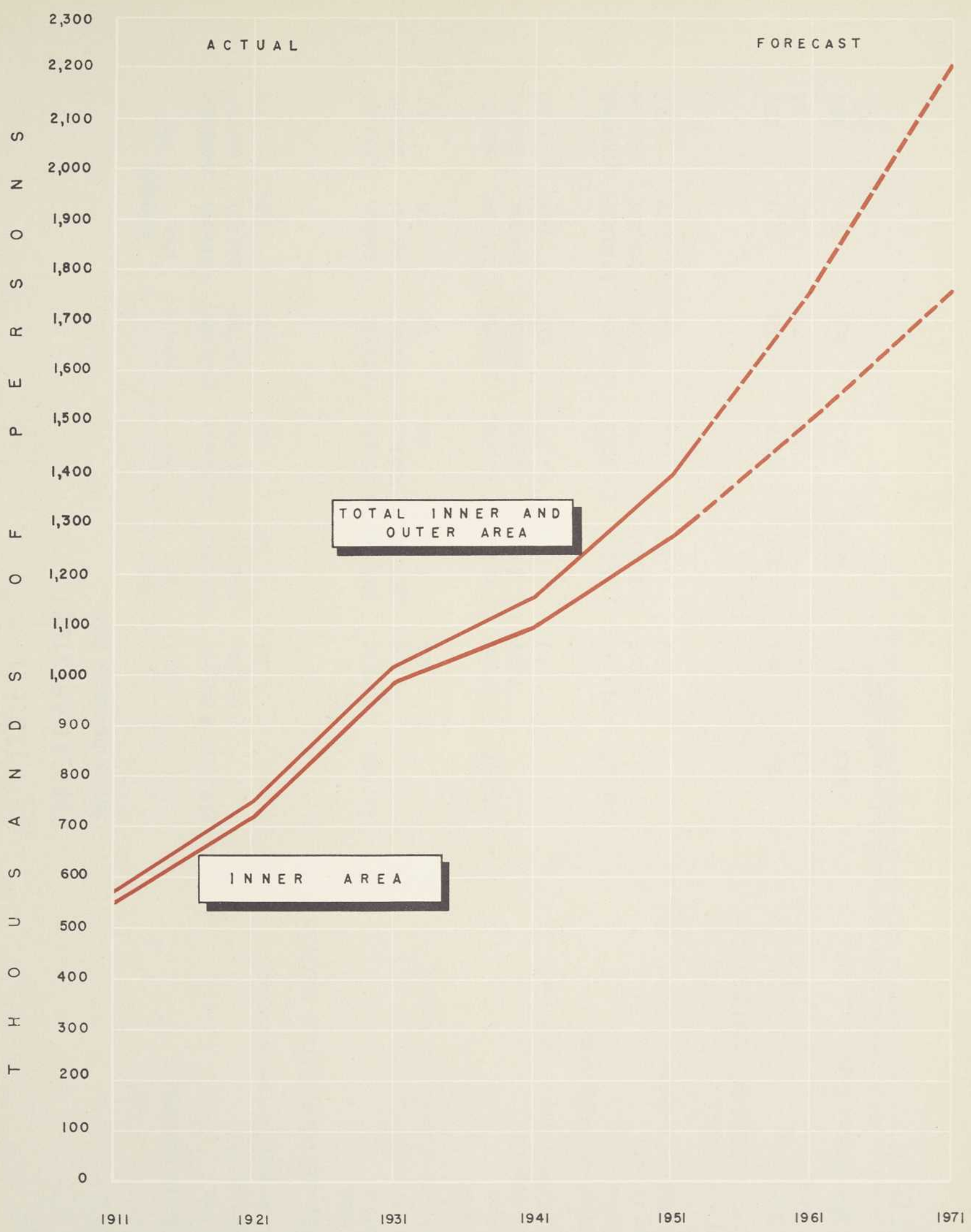
At the turn of the present century, fifty years ago, Montreal's population aggregated a quarter of a million people, fewer than now live in the fast-growing suburban areas. The present metropolitan population (1953) is estimated to be almost one and one-half millions. A twenty-year forecast indicates a probable population, by 1971, of two million two hundred thousand.

Trends in population growth of Montreal and the Montreal metropolitan region are of great importance in projecting immediate and long range plans for transportation. Forecasts are needed, not only of total population, but also of its distribution. It was necessary to consider the topographical, cultural, industrial, and commercial features of the area, therefore, in predicting Montreal's future growth and development.

For the purposes of this report, the metropolitan region of Montreal has been defined as the City of Montreal and forty-three surrounding cities, towns, villages, and parishes as shown in Appendix A. For the purpose of analyzing population growth and distribution, the metropolitan region has been divided into an inner and an outer area. This outer area includes bordering sections which will become of increasing importance in the metropolitan scene during the next generation, particularly communities along the shores of Rivière des Prairies and those on the south shore of the St. Lawrence River. Exhibit 1 shows the location of the various municipalities comprising the metropolitan region and indicates the division of the region into inner and outer areas. The past growth in population of the Province of Quebec and of the metropolitan region are shown on Table 1. This tabulation summarizes the significant data used in forecasting future growth. The graph shown on Plate 1 indicates the past growth and estimated future growth of the metropolitan population.

In developing estimates of probable future distribution of people throughout the metropolitan area, analyses were made of past growth of segments within Montreal City as well as in all cities, towns, villages, and parishes of both the inner and outer areas. The numerical and percentage growth of each and their relation to the totals of other segments were analyzed. These studies are set out in summary form in Appendix A.

Other factors considered were recent trends in community growth, availability of suitable land for residential purposes, probable industrial expansion, railroad and harbour facilities, parks, topo-



FORECASTS OF POPULATION



TABLE 1
POPULATION STUDY
Montreal Metropolitan Region

	Actual					Estimated	
	1911	1921	1931	1941	1951	1961	1971
PROVINCE OF QUEBEC							
Population	2,005,776	2,360,510	2,874,662	3,331,882	4,005,681	5,000,000	6,000,000
10-year Growth		354,734	514,152	457,220	723,799	944,319	1,000,000
Annual Rate of Increase in Percent		1.9	2.0	1.8	2.0	2.0	2.0
MONTREAL METROPOLITAN REGION							
<i>Inner Area</i>							
Population	541,020	707,233	983,100	1,092,953	1,273,540	1,500,000	1,750,000
10-year Growth		166,213	275,867	109,853	180,587	226,460	250,000
Annual Rate of Increase in Percent		3.0	3.3	0.9	1.8	2.0	1.7
<i>Outer Area</i>							
Population	25,517	33,209	42,143	53,512	123,434	250,000	450,000
10-year Growth		7,692	8,934	11,369	69,922	126,566	200,000
Annual Rate of Increase in Percent		3.0	2.7	2.7	13.1	10.3	8.0
<i>Total Inner and Outer Areas</i>							
Population	566,537	740,442	1,025,243	1,146,465	1,396,974	1,750,000	2,200,000
10-year Growth		173,905	284,801	121,222	250,509	353,026	450,000
Annual Rate of Increase in Percent		3.0	3.4	1.1	2.0	2.2	2.2
PERCENT OF TOTAL PROVINCE OF QUEBEC POPULATION							
Inner Area	27.0	30.0	34.2	32.8	31.4	30.0	29.2
Outer Area	1.3	1.4	1.4	1.6	3.0	5.0	7.5
Total Metropolitan Region	28.3	31.4	35.6	34.4	34.4	35.0	36.7

Data for years 1911 to 1951 inclusive are taken from Dominion Census Records.
No allowance has been made in the estimated figures for the effect of the deep waterway on the Montreal Area.

graphical features, and existing and likely future public transportation and highway facilities. All of these combined have been weighed in determining the probable distribution of people in the metropolitan region. A population spot map, Exhibit 2, shows the existing distribution (1951) and the distribution anticipated in 1971 in the inner area.

TRAFFIC

The most significant aspect of the traffic and public transportation situation is the rapid rise in the number of motor vehicles registered and increase in their use during the past few years.

In 1945, the Island of Montreal had 85,411 motor vehicles. In 1951, the number was approximately 171,000. Considering the City of Montreal alone there were, in 1945, 7.08 motor vehicles per 100 persons but in 1951, the ratio had nearly doubled to 13.20 motor vehicles per 100 persons. There is every indication that this upward trend will continue in Montreal. Other large cities have much greater motor vehicle ownership. Plate 2 shows these data for the Montreal area and other comparable cities.

Coincident with increasing commercial activity, the use of trucks for the delivery of merchandise and materials will undoubtedly continue to increase. It should be noted, furthermore, that taxicab permits in the City of Montreal alone number 4,295. The ratio is 4.20 taxicabs per 1000 persons. With the exception of Washington, D.C., this ratio far exceeds that of any other large city on the continent. Taxicabs must be considered an important element of Montreal traffic.

PUBLIC TRANSIT

The Montreal Transportation Commission renders local transportation service in Montreal and in seventeen surrounding municipalities. See Exhibit 2. Eighty-four square miles of the metropolitan region are served by the Commission's vehicles. The system comprises a coordinated network of streetcar, trolleybus, and autobus lines employing 1,675 passenger vehicles operating over 266 miles of streets. Table 2 shows the yearly revenue passengers carried, vehicle-miles operated, and riding habit — it indicates the magnitude and stability of public transportation in the Montreal traffic picture. The system is being constantly expanded to meet, as far as is economically possible, the requirements of the population.





TRENDS IN MOTOR VEHICLE OWNERSHIP
PER ONE HUNDRED PERSONS



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Passenger traffic within the metropolitan region, by main railroads and interurban buses, is not an outstanding characteristic of Montreal traffic, although it is increasing. The Canadian National Railways are continually augmenting their Mount Royal tunnel service, which links the centre of Montreal with some of the northern sections of Montreal as well as with the Towns of St. Laurent, Mount Royal, St. Michel, and Montreal North.

The Mount Royal tunnel services must be considered, however, part of the local transportation facilities, functioning to a certain extent as rapid transit services to neighbouring areas north of the Mountain.

Also within the metropolitan region, the Canadian Pacific Railway Company furnishes service between Windsor Station and the City of Westmount and the Town of Montreal West.

TABLE 2
PUBLIC TRANSIT IN MONTREAL
Revenue Passengers, Vehicle-miles Operated, and Rides Per Capita
1931 to 1952 Inclusive

Year	Revenue Passengers	Vehicle-Miles	Rides per Capita
1931	232,141,103	33,325,119	233
1932	210,807,129	32,418,558	209
1933	196,141,103	31,236,766	193
1934	197,620,176	31,063,762	192
1935	195,890,771	31,163,017	188
1936	198,626,907	31,622,124	189
1937	208,208,793	32,640,470	196
1938	208,261,207	32,455,464	194
1939	208,928,429	32,509,621	192
1940	225,764,051	33,733,468	206
1941	263,571,788	37,812,491	238
1942	319,398,324	42,841,458	283
1943	354,359,555	45,227,386	309
1944	361,042,941	45,587,111	309
1945	385,575,041	47,870,198	325
1946	396,480,489	50,215,288	329
1947	398,349,773	51,247,404	326
1948	398,271,535	51,335,643	320
1949	396,087,032	50,643,565	315
1950	370,113,954	50,294,674	289
1951	369,936,085	51,257,534	284
1952	367,311,147	53,003,641	278



Craig Street — Looking East from St. Lawrence Boulevard

CAUSES OF CONGESTION

Traffic congestion in the central business district of Montreal is apparent to everyone. Volume and density of traffic have increased steadily since the end of the last war. This is the natural result of increasing population, private automobile ownership, and motor transport activity.

For the purposes of this report, the central business district is defined as the area bounded by Guy Street, Sherbrooke Street, St. Denis Street, and the waterfront.

While the city and suburbs have been expanding outward in all directions, the traffic capacity of streets in the central business district is virtually the same as fifty years ago, with few exceptions. The picture then is that more and more people, from a wider and wider area, are doing business, working, and seeking entertainment in the same central core of the city with its limited street space.

This situation is not unique to Montreal. Every large city on this continent is trying desperately to solve, or at least alleviate, its downtown traffic problem. There are aspects of local topography and climate, however, which make the problem in Montreal perhaps more acute and perplexing than in other cities of equal size.

Most of the central business district of Montreal is confined between two physical barriers — the Mountain on the north and the St. Lawrence River on the south. Because of this northern barrier, there are no arteries projecting northward from the business area between Bleury and Guy Streets — a distance of one mile. All north-south streets in this sector must come to a dead end at Sherbrooke Street or at Pine Avenue.

All of the traffic entering or leaving this important part of the business district must use east-west thoroughfares. Also, because of the Mountain, much east-west traffic is forced to pass through the central area. This topographical situation produces extreme concentration of traffic on east-west streets in the central area. These are relatively few — Pine, Sherbrooke, St. Catherine, Dorchester, Craig, St. Antoine, and St. James—Notre Dame combination, all of which must bear heavy concentrations of vehicles of all types.

Another topographical feature which affects traffic movement to and from the central area is the conformation of the land lying between the Mountain and the River. From Craig Street there is a rise of from 40 to 80 feet to the Dorchester—St. Catherine level in the midtown section, with a further rise of 90 to 150 feet between St. Catherine Street and Pine Avenue. Also, a sharply defined rise is encountered between Ontario and Sherbrooke Streets on all north-south streets from Bleury Street eastward. On the west side of the Mountain the Côte des Neiges Road outlet presents a long steep grade. The negotiation of these grades during winter months is frequently difficult for motor vehicles. The presence of these short but rather sharp slopes adds appreciably to congestion and delays in the central area under conditions of ice or snow.

With the exception of Leningrad, Montreal has a greater annual snowfall than any other city in the world of over one million population. The average annual snowfall over the past 78 years has been 111 inches. In spite of the excellent and modern methods of clearing and removing snow by the city's Department of Roads, there is necessarily a period of time after each storm when streets in the central area, already narrow, are further constricted by banks of snow.

All these local elements — topography, street pattern, and climate — combine to produce extreme congestion in the central business district.



St. Catherine Street
Near Guy Street
Looking West



St. Lawrence Boulevard
Near Van Horne Avenue
Looking South

Jean Talon Street
at Querbes Avenue
Looking East



A cordon count of all vehicles and passengers outbound from the central business area between 5:00 P.M. and 6:00 P.M. made in March 1953, shows that 17,348 vehicles of all types left the area bounded by Guy Street, Sherbrooke Street, St. Denis Street, and the waterfront, in that one hour. These vehicles carried a total of 82,842 passengers. A breakdown of this traffic by type is given in the following tabulation.

TABLE 3
VEHICLES AND PASSENGERS OUTBOUND
FROM THE CENTRAL BUSINESS DISTRICT
Between 5 P.M. and 6 P.M. on a Typical Weekday in March 1953

	Vehicles		Passengers		
	Number	Percent of Total	Number	Percent of Total	Average per Vehicle
Private autos	11,340	65	21,276*	25	1.88*
Taxis	3,189	18	3,066	4	0.96
Montreal Transportation					
Commission Vehicles	725	4	55,540	67	76.60
Provincial Transport Co.	71	1	1,345	2	20.07
Montreal and Southern					
Counties Railway	29	0	1,615	2	55.69
Commercial Vehicles	1,994	12	—	—	—
Total	17,348	100	82,842	100	

*Includes driver

It is significant that 58,500 or 71 percent of the total outgoing passengers were carried by the various public transportation agencies.

Comparison with similar counts made in 1945, Plate 3, show that the number of automobiles and taxis has increased by almost 85 percent.

The proper working capacity of several congested intersections in the central area has been determined. Results indicate that some of the approaches to busy intersections are saturated beyond their working capacity under present conditions. The effect, of course, is well known and is manifested by periods of virtual standstill for all vehicles.

Traffic congestion in the central area, while most severe during rush hours, is by no means confined to these periods. It is common to see congested conditions on the main arteries throughout the day. For example, on Craig Street in the vicinity of Bleury Street the total traffic passing in both directions between 7:00 A.M. and 7:00 P.M. amounts to 14,006 vehicles. The distribution by hours of the day is given below, and shows almost a constant flow.

CRAIG STREET BETWEEN ST. URBAIN AND BLEURY STREETS

Hourly Vehicle Count in Both Directions on a Typical Weekday

<u>Period</u>	<u>Number of Vehicles All Types</u>	<u>Percent of 12-Hour Total</u>
7:00 — 8:00 A.M.	875	6.2
8:00 — 9:00	1,124	8.0
9:00 — 10:00	1,228	8.8
10:00 — 11:00	1,327	9.5
11:00 — 12:00 Noon	1,254	9.0
12:00 — 1:00 P.M.	1,005	7.2
1:00 — 2:00	1,139	8.1
2:00 — 3:00	1,380	9.8
3:00 — 4:00	1,298	9.3
4:00 — 5:00	1,282	9.2
5:00 — 6:00	1,222	8.7
6:00 — 7:00 P.M.	872	6.2
Total — 12 Hours	14,006	100.0

Other examples of the steady flow of traffic are given in the following tabulation, which shows the number of vehicles of all types passing through the intersections of St. Catherine and Peel Streets and St. Catherine and St. Denis Streets, during a typical weekday in May 1953.

Turning now to areas outside the central business district, the Mountain, the large cemeteries, and Westmount Mountain present natural barriers to the growing traffic. To the southwest much has been accomplished by the construction of tunnels under the Lachine Canal, but this canal still constitutes a barrier to the free movement of traffic.

With the population growth in the outlying parts of the City and suburbs it is natural to expect a continued increase in traffic volume with resultant congestion in many centres. This trend is particularly noticeable on main arteries leading to and from the central business district. Park Avenue, St. Hubert Street, Côte des Neiges Road, and Sherbrooke Street are typical examples of heavy and congested movement of traffic during rush periods.

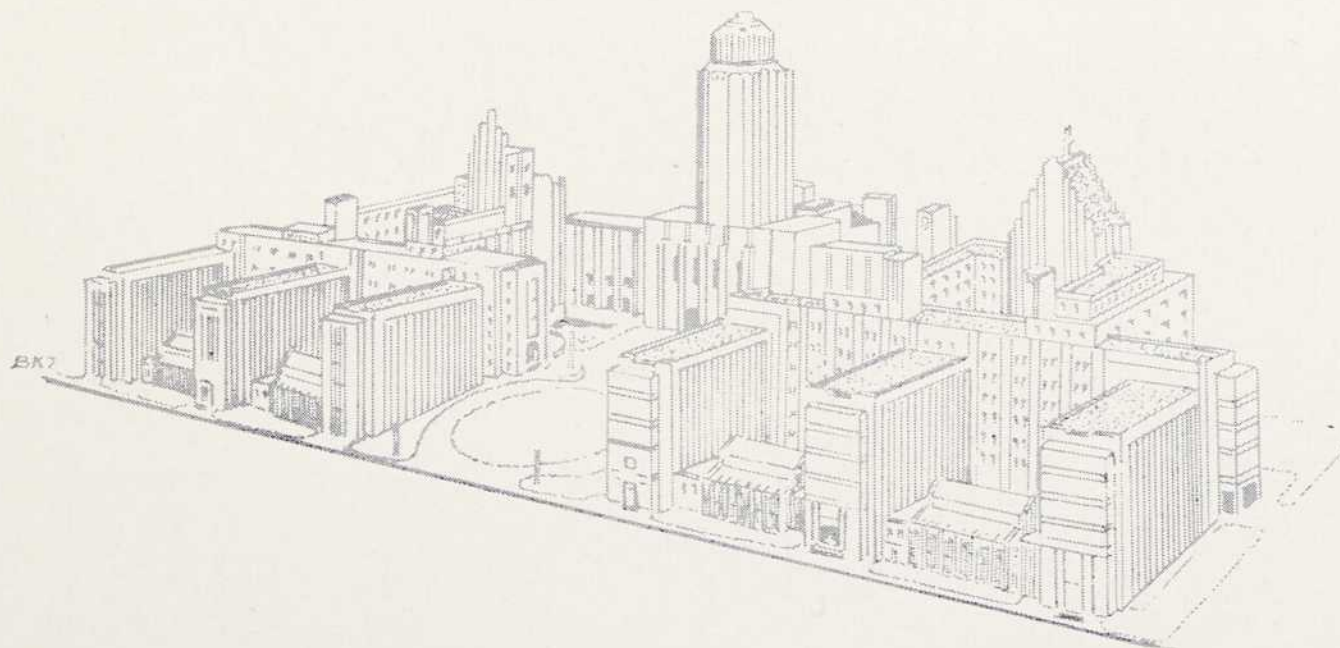


NUMBER OF VEHICLES LEAVING THE CENTRAL BUSINESS DISTRICT
5 P.M. TO 6 P.M.

HOURLY VEHICLE COUNT

All Directions on a Typical Weekday

Period	Intersection of St. Catherine and Peel Streets		Intersection of St. Catherine and St. Denis Streets	
	Number of Vehicles All Types	Percent of 12-Hour Total	Number of Vehicles All Types	Percent of 12-Hour Total
7:00 — 8:00 A.M.	592	3.4	899	5.7
8:00 — 9:00	1,620	9.2	1,292	8.2
9:00 — 10:00	1,655	9.4	1,431	9.1
10:00 — 11:00	1,476	8.4	1,302	8.3
11:00 — 12:00 Noon	1,488	8.5	1,101	7.0
12:00 — 1:00 P.M.	1,502	8.6	993	6.3
1:00 — 2:00	1,384	7.9	1,373	8.7
2:00 — 3:00	1,551	8.8	1,631	10.3
3:00 — 4:00	1,660	9.5	1,598	10.1
4:00 — 5:00	1,662	9.5	1,537	9.8
5:00 — 6:00	1,702	9.7	1,545	9.8
6:00 — 7:00 P.M.	1,239	7.1	1,058	6.7
Total — 12 Hours	17,531	100.0	15,760	100.0





Windsor Street
Looking North
from St. Antoine Street

EFFECTS OF CONGESTION ON PUBLIC TRANSIT

The peculiarities of topography and street pattern produce an extremely difficult condition for public transportation service. Very few of the existing streets are suitable for transit vehicles. Consequently, many routes must overlap and be concentrated on such arteries as St. Catherine, Craig, St. James, and Bleury Streets. There are relatively few outlets from the 1.6 square mile downtown area previously described. As a result, a very high volume of streetcar and bus passengers must be channelled through a few such congested intersections as St. Catherine and St. Denis, St. Catherine and St. Lawrence, St. Catherine and Bleury, St. Catherine and Guy, Craig and St. Denis, St. James and Windsor, and Dorchester and Windsor. Even with the most intensive working of these intersections, congested and crowded conditions prevail.

The unsatisfactory speed of travel for public transportation passengers is demonstrated by the following actual average speeds during rush hours.



Notre Dame Street
Looking West
from Place d'Armes

ACTUAL AVERAGE TRAVEL SPEEDS BY PUBLIC TRANSPORTATION IN THE CENTRAL AREA

On	From	To	Distance (Miles)	A.M. Rush		P.M. Rush	
				Time (Minutes)	Speed (MPH)	Time (Minutes)	Speed (MPH)
Notre Dame West	Colborne	Place d'Armes	0.709	9.4	4.55	9.4	4.55
Notre Dame East	Place d'Armes	Gosford	0.352	3.1	6.74	3.5	6.06
St. James East	Place Jacques Cartier and Notre Dame	Place d'Armes	0.312	4.2	4.51	8.0	2.33
St. James West	Place d'Armes	Windsor	0.714	9.1	4.72	13.4	3.21
St. Antoine and Craig West	Windsor	Craig Terminus	0.736	7.7	5.75	8.6	5.14
Craig East	St. Denis	Craig Terminus	0.513	5.6	5.46	5.8	5.26
Guy and Dorchester West	Guy and St. Catherine	University	0.831	8.8	5.67	8.5	5.88
St. Catherine	Guy	St. Denis	1.544	14.4	6.43	19.6	4.72
Ontario	St. Denis	Aylmer Terminus	0.910	7.4	7.40	9.5	5.75
Bleury	Craig	Ontario	0.493	5.8	5.13	9.1	3.24
McGill	Wellington	Craig	0.364	4.4	4.94	5.7	3.85
St. Lawrence	Craig	Ontario	0.552	4.2	7.89	6.0	5.54
St. Denis	Ontario	Craig	0.624	5.3	7.02	5.6	6.63

The average travel time for public transportation passengers between the central and outlying areas has been steadily increasing due to traffic congestion. Typical examples are shown in the following tabulation:

**ACTUAL AVERAGE RUSH HOUR TRAVEL TIME
OF SURFACE TRANSIT SERVICE BETWEEN THE
CENTRAL AREA AND TYPICAL OUTLYING POINTS**

<u>From</u>	<u>To</u>	<u>Miles</u>	<u>Time in minutes</u>	<u>Miles per Hour</u>
Aylmer Terminal	Viau and Notre Dame	4.67	36	7.8
Place d'Armes	Bon-Air and de Lorimier	5.05	38	8.0
Craig Terminal	Sault au Recollet	9.00	57	9.5
Youville Square	Garland Terminal	7.18	58	7.4
Craig Terminal	Somerled and Walkley	6.07	46	7.9
Place d'Armes	Rosemont and 26th Avenue	5.84	42	8.4
Place d'Armes	Wellington and Woodland	4.00	40	6.0
Craig Terminal	Ogilvy and Querbes	4.00	37	6.5
Craig Terminal	Hillsdale	4.41	40	6.6
Place d'Armes	Westminster and Parkside	6.73	64	6.3

TRAFFIC IMPROVEMENTS

Many measures have been adopted to improve the efficiency of the existing street system both within and without the central business area. Such measures as one-way streets, abolition of left turns, prohibition or limitation of parking, restriction on the hours of commercial delivery, pavement markings, stop streets, and various traffic control devices have been extremely helpful. Certainly conditions would be much worse if they had not been applied.

Furthermore, the Traffic Division of the Montreal Police Department is outstanding in the field of traffic control and administration methods. This organization has accomplished very commendable work in the central area under difficult physical conditions.

Improved street facilities which the City has executed, such as street widenings, curb cut-backs and the projection of University Street southward, have afforded much relief. The major project of widening Dorchester between Atwater and Windsor and between Beaver Hall Hill and de Lorimier will provide a much needed east-west facility.

Nevertheless, it must be emphasized that street widenings and new streets, while affording temporary relief, can never satisfactorily solve the mass transportation problem in the central area. Experience has shown that such new facilities have a disconcerting way of filling up soon after they are created inasmuch as additional traffic is encouraged to circulate in the centre of the city. It is essential in any plan for rapid public transportation that exclusive channels be established, as provided by subways. Such facilities would, at the same time, improve surface traffic and reduce the pressure for more space for auto movement and parking.

CONCLUSION

The Montreal Transportation Commission is in agreement with the 1949 report of the City of Montreal's Board of Research on Traffic and Transportation Problems, where it states on page 61:

"One solution remains: The construction of a network of underground arteries for mass transportation vehicles, i.e., two-level streets permitting the separation of high capacity transportation from all other traffic. In other words a subway."



CHAPTER II

SUBWAYS FOR MONTREAL

OTHER PROPOSALS

Out of the welter of discussions on the subject of traffic relief during the past three decades there have evolved numerous plans for the amelioration of the existing and rapidly worsening traffic congestion in central Montreal. Many of these studies related to those improvements in the functional use of the streets which could be accomplished with relatively limited financial outlays, and the city has already made effective most of them. They include restriction of curb parking, installation of modern traffic control signals, one-way streets, and channelization of intersections. Further improvements can be made through the extension of these measures, but they will be relatively minor in view of the rapidly increasing number of vehicles operating on the public streets. Perhaps the greatest potential gain may be accomplished through the complete abolition of parking on all thoroughfares in the central district and on the principal avenues of approach.

Additional capacity of the existing street system will be provided by widening improvements such as Dorchester Street, and other similar projects. Many other improvements have been incorporated in the Master Plan for Montreal and each will provide some measure of additional capacity and improved fluidity of traffic movements.

At best, however, such improvements constitute only a partial and inadequate cure for a major ailment. Of more real importance are the expressways which have been proposed in 1949 by the City Planning Commission and approved by the Montreal Board of Research on Traffic and Transportation Problems.

One of these is the expressway to be located just north of, and generally parallel to, the St. Lawrence River. This projected grade-separated thoroughfare will serve a most useful function in expediting east and west traffic movements. It will provide a facility to permit east-west traffic to by-pass the central business district.

The other is the Metropolitan Boulevard project, a splendid conception of a grade-separated highway for circumferential traffic movements. It will be a noteworthy addition to Montreal's circulatory system.

Both these projects are soundly conceived and will constitute substantial improvements of lasting benefit. Neither of them, however, will solve the problem of coping with the mass movements to and from shopping and business districts. It must be recognized that the construction of expressways into the heart of the city from outlying areas serve but to attract enormous flows of passengers in individual automobiles. Eventually these people must leave the expressway and travel to their ultimate destinations on the crowded and congested local street system. Transportation planners have appreciated that to greatly expand the capacity of the local street system and to provide adequate off-street parking facilities would be impossible from the viewpoint of the financial and physical problems involved.

The Commission believes that mass radial movements to and from residential and commercial districts can best be provided by public transit.

A SYSTEM OF RAPID MASS TRANSPORTATION NEEDED

Need for subways in Montreal has long been recognized. Formal expression of this need is found in a number of reports, including "A Report on a Subway Plan for Montreal" prepared for the Greater Montreal Economic Council by the Montreal Tramways Company in May 1944; "A Report of the Greater Montreal Economic Council" presented at a general meeting on April 15, 1946; and in a report prepared in 1949 by the Montreal Board of Research on Traffic and Transportation Problems. A comprehensive system of subways based largely on these previous reports is also included in the tentative master plan as prepared by the staff of the Montreal City Planning Commission.

All these studies and reports culminated in the mandate to the Montreal Transportation Commission to prepare a report including plans, estimates of cost, and a financial program for a system of rapid mass transportation.

There is complete agreement among the earlier plans that, as a minimum, the essential parts of a rapid transit system should consist of the following subways: a north-south route, an east-west route, and a downtown distributor. The system recommended herein has been based on more exhaustive studies than were possible in the previous reports. It will be found, however, that these basic elements are still the foundation of the proposed rapid transit system for Montreal. In addition, extensions of the basic routes to form a more comprehensive system can now be planned with confidence, since the probable directions of future growth of the city have recently become manifest.



PURPOSE OF REPORT

A system of rapid mass transportation is planned to meet the twin problems of serving a growing population and providing improved service despite rapidly increasing traffic congestion. Several considerations influence selection of the recommended system. Adequate service to the community is of prime importance. This includes service to established residential, commercial, and industrial areas, as well as provision of transit routes in the rapidly growing outlying areas. It is vital, also, that established property values be protected by improving the accessibility of the central business district and other focal areas. In addition to the requirement of adequacy, and perhaps of even greater importance, is the need for speed, safety, comfort, convenience, and other features of attractive modern public transportation.

The cost of construction is another factor that cannot be overlooked. Comparative cost studies were made, therefore, not only of subways in various alternate locations, but also of the relative cost of high-level versus low-level subways and of structures built by cut-and-cover as against those built by tunnelling methods. In a city with the interesting geological history and topography of Montreal, such studies are of utmost importance in planning for subways.

The system of subways recommended cannot be built in its entirety within the immediate future. The purpose of this report is to select and recommend a portion of an entire subway system for the first stage of construction and having decided on this portion to study in detail the construction problems and to accurately calculate the cost.



CHAPTER III

THE INITIAL SUBWAY PROJECT

SUBWAY EAST OF THE MOUNTAIN

From the distribution of population shown on Exhibit 2, it is apparent that a subway lying east of the Mountain and extending northward from the central business district would bring the greatest benefits to the greatest number.

The selection of this area for the initial subway is also confirmed by the number of passengers presently carried on transit lines on Bleury—Park Avenue, St. Urbain Street, St. Lawrence Boulevard, St. Denis Street, and St. Hubert Street.

These five streets jointly are used by 190,000 transit passengers daily, 26,000 of whom travel during the maximum hour from 5:00 to 6:00 P.M. This group is larger than any other travelling in one general direction for a considerable distance.

INITIAL SUBWAY ROUTE

It is recommended that the initial subway be constructed along the following route:

Along St. Denis Street, from a terminal on the Commission's property north of Crémazie Boulevard, to Craig Street; west on Craig Street and diagonally under Champ-de-Mars to St. James Street; west along St. James Street to Inspector Street. From this point northward, passing diagonally through Dominion Square to the intersection of Peel and St. Catherine Streets; west on St. Catherine Street to Atwater Avenue. See Plate 4.

Factors leading to the above conclusions regarding the location and extent of the initial subway are discussed in this chapter.

LOCATION OF NORTH—SOUTH ROUTE

To determine the precise location of a north-south subway route, all feasible locations between Park Avenue and St. Hubert Street were appraised from the viewpoints of passenger use and passenger advantage.

Consideration was given to Park Avenue, St. Lawrence Boulevard, and St. Denis Street. Several variations were explored, including studies of several outer terminals. In all, eight alternative plans were developed and studied.

Surface routes were laid out for each plan. They were designed to carry passengers to and from the subway stations as quickly and conveniently as possible. This feature is extremely important as it will determine the value of the subway to people residing beyond walking distance on either side.

In this respect the advantages of the routes under consideration were compared. In general, Park Avenue and St. Lawrence Boulevard are more easily reached from areas to the west and behind the Mountain, while St. Denis Street is more accessible to persons residing in the eastern areas, particularly in the Rosemont district.

At this stage of the study, Park Avenue was eliminated as a potential subway route for the following reasons:

- (a) The population adjacent to Park Avenue between Van Horne Avenue and Jean Talon Street is rather low, this section being of a scattered industrial nature.
- (b) At Jean Talon Street the population immediately west of Park Avenue comes under the influence of the Canadian National Railways' Mount Royal Tunnel service. This tunnel is functioning more and more efficiently as a rapid transit route serving the Town of Mount Royal and nearby areas of Montreal and Ville St. Laurent. It is to a certain extent a part of Montreal's rapid transit pattern.
- (c) Assuming that a north-south subway should touch the Place d'Armes district and then swing northwest to St. Catherine Street, as in former plans, Park Avenue appears unsuitable. Turning west from Bleury Street, the first downtown station would be near Victoria Square—a considerable distance from Place d'Armes, City Hall, Court House, and other important points.

The remaining choices, St. Lawrence Boulevard and St. Denis Street, were compared as to probable daily passenger use. These studies established the "region of influence" of each, that is, the territory more quickly reached by subway and surface lines than by surface lines alone by a passenger starting from Place d'Armes or Craig Terminus. By comparing the population in these territories and applying the present riding habit factor, (0.418 one-way rides per capita per day), the total number of potential subway passengers per day is estimated as follows:

St. Lawrence subway.....	265,000 passengers per day
St. Denis subway.....	261,000 passengers per day

As might be expected, these streets being parallel and only 1,650 feet apart, there is practically no difference in the number of passengers who would be served.

Computations were then made of the difference in passenger travel time saved due solely to the location of the subway, based on a common point near Place d'Armes and Craig Terminus. The results indicate that potential subway passengers east of St. Denis Street would save 4,219 *more* hours daily, if the subway was on St. Denis Street instead of St. Lawrence. Potential subway passengers west of St. Lawrence Boulevard would save 3,496 *more* hours if the subway was placed on St. Lawrence instead of St. Denis. The difference, 723 hours, is slightly in favor of the St. Denis Street location.

So far, the comparison between St. Lawrence Boulevard and St. Denis Street for a subway location has been directed primarily to the section between Craig Street and Jean Talon. North of Jean Talon Street, however, St. Denis Street appears more favorable than St. Lawrence Boulevard because of greater adjacent population. See Exhibit 2.

Off-street transfer stations permit passengers to change from surface lines to subway and vice versa without the delay of presenting transfers. They offer distinct advantages, both to passengers





FIGURE 1. THE EXTENT OF THE
RESEARCH AREA



and to general street traffic. Neither St. Lawrence Boulevard nor St. Denis Street present very many opportunities for adequate stations without the acquisition of private property.

Considering the section between Craig Street and Crémazie Boulevard, each street passes near the Commission's Youville property where such facilities could be provided equally well for either subway location. Another opportunity exists on St. Denis Street at de Fleurimont Street where a portion of the Commission's property could be used for a transfer station. This is considered important as large numbers of Rosemont passengers will connect with the subway at this point via Rosemont Boulevard and de Fleurimont Street. This feature is therefore in favor of the St. Denis Street location.

A further advantage of St. Denis Street over St. Lawrence Boulevard lies in the fact that a station could be placed near the civic buildings in the vicinity of Gosford Street where are located City Hall, City Hall Annex, Court House, and the former Place Viger Hotel; also Bonsecours market, numerous wholesale establishments, Victoria Pier and other important harbour facilities.

For the above reasons it was concluded that St. Denis Street should be selected.

EXTENT OF NORTH—SOUTH SUBWAY

Several locations for the initial outer terminus of a St. Denis subway were considered, such as the St. Denis yard just south of de Bellechasse Street, Jean Talon Street, and Crémazie Boulevard.

Considering the large number of people who would be obliged to travel long distances to reach the subway if it terminated at de Bellechasse Street, this point was abandoned early in the study. Jean Talon Street is considered to be the minimum distance northward to which the initial subway should be built.

It is highly desirable that the outer terminal of the subway be at a point where passengers from many directions may converge directly and rapidly by surface routes. Jean Talon and Bélanger Streets offer this facility because they are east-west arteries. The next important east-west thoroughfare is Crémazie Boulevard, 1.27 miles farther north.

To reach a decision on the northern limit of the subway it was necessary, therefore, to appraise the usefulness and benefits of building the section between Jean Talon Street and Crémazie Boulevard at the present time.

Consideration must be given also to the availability of a large tract of land required for storage, servicing, and maintenance of car equipment near the terminal.

Based on the residential population north of Jean Talon Street and the known riding habits to and from the central area, it is estimated that approximately 42,000 passengers per day would be carried in the subway between the central area and the area north of Jean Talon Street. It is expected that this figure would be exceeded by the time the subway would be in operation. Furthermore, with the construction of Metropolitan Boulevard, and if parking facilities were provided at the subway terminal, motorists from many suburban communities would be attracted to the subway for the city portion of their journey.

The north-south surface lines in this sector of the city, namely St. Lawrence, St. Denis, St. Hubert, and Christophe Colomb, now carry 87,000 passengers daily north of Jean Talon Street. This is 45 per cent of the 190,000 north-south passengers at Sherbrooke Street. While a large proportion of these 87,000 passengers do not travel to or from the central area, they are nevertheless potential subway passengers. The estimated 42,000 passengers who would use the subway to and from the central area initially, then, would be augmented by other users to bring the daily total north of Jean Talon Street to an estimated 65,000 passengers.

Aside from the potential usage of this section of the subway, there would be substantial time savings for passengers living north of Crémazie Boulevard if they could enter and leave the subway at that point rather than at Jean Talon Street. Total daily passenger-time saved is calculated to be 1,565 hours for residents north of Jean Talon Street including such areas as Bordeaux, Ahuntsic, and Montreal North.

Facilities for the servicing, maintenance, and storage of rapid transit cars can be provided most adequately if the subway extends to the proposed terminal located on the property now owned by the Commission to the north of the Youville shops. This will afford an opportunity to build an efficient and convenient station for transfer between surface routes and subway on the Commission's property about 2,000 feet north of Crémazie Boulevard.

It is concluded that the initial north-south subway on St. Denis Street should extend from a transfer terminal on the Commission's property north of Crémazie Boulevard to Craig Street. This terminal was selected for the following reasons:

- (a) Density of population is well sustained to this point and trend of growth is northward.
- (b) Areas between Crémazie and Gouin Boulevards and communities along Rivière des Prairies will be afforded reasonably quick contact with the subway.
- (c) Metropolitan Boulevard will be constructed along the line of Crémazie Boulevard allowing extensive distribution of subway passengers east and west.
- (d) A convenient location exists on the Commission's property for an off-street transfer station and for the establishment of a parking lot.
- (e) The Commission's property furnishes an adequate site for subway car maintenance and storage facilities.

LOCATION IN CENTRAL DISTRICT

The central business district of Montreal is composed primarily of a strip, two miles in length, of retail establishments, offices, and places of amusement, centered closely on St. Catherine Street. Most of the large hotels and the railway stations are also in this vicinity. At a lower level and about one-half mile to the south lies a more compact business area containing office buildings, financial institutions, wholesale firms, and some manufacturing. This area also contains the City Hall, Court Houses and other civic buildings, as well as docks and warehouses.

This distribution of business activity has always presented a difficult problem in previous plans for locating the central portion of a north-south subway.

The present study provides that the north-south subway turn west on reaching the vicinity of Craig Street and continue west to the vicinity of Inspector Street, where it would again swing north to the intersection of St. Catherine and Peel Streets.

In this way the subway would intersect St. Catherine Street at two points, namely, at St. Denis Street and at Peel Street. At the same time it would embrace the downtown financial district. In the latter district, both Craig Street and St. James Street have been considered previously as subway locations.

It has been determined from various surveys that St. James Street is nearer to most workers than Craig Street. Even considering the strip between St. James and Craig Streets as neutral, the area south of St. James Street to the river contains more daytime people than the area north of Craig Street to, say, Lagauchetière Street.

Most of the larger and more important office buildings in the financial district are located on or in the immediate vicinity of St. James Street. Place d'Armes is—except for the Craig Terminal—the most important focal point in the area. With the transfer to the subway of a substantial proportion of the traffic now carried on the Park, St. Lawrence and St. Denis trunk lines, the Craig Terminal will decrease in importance. From the viewpoint of convenience of transit passengers, Place d'Armes is the ideal location for the principal station in the downtown district. A plan for such station has been developed—to be described subsequently—which will provide convenient facilities for interchange of passengers between Craig Terminal, Craig Street, and Place d'Armes.

St. James Street has substantial advantages in regard to physical problems involved in constructing a subway. To some extent, the final recommendation on location of the downtown distributor route was based on construction problems. While a subway in either Craig or St. James Streets was considered, it was found that there would be more physical difficulties involved in building a subway in Craig Street. Much of the route would need to be constructed below ground-water level, large trunk sewers would have to be rebuilt, and the foundations of adjacent buildings would have to be underpinned, partly under water.

From the view point of convenience to the greatest number of downtown workers, therefore, as well as minimizing the cost of construction, it is concluded that St. James Street has substantial advantages over Craig Street.

EXTENSION WESTWARD

As outlined above, the first section of the subway would follow St. Denis Street from a terminal north of Crémazie Boulevard to Craig Street. It would continue westerly via St. James and thence northwest to the corner of Peel and St. Catherine Streets.

A subway terminal at this intersection would become a heavy point of origin and destination for west-end residents, for passengers originating in the St. Denis subway, and for those travelling between the uptown and downtown sections of the business district. Large numbers of west-end passengers travelling to and from the financial district and points in the north and east sections would transfer at Peel and St. Catherine Streets if that were made the subway terminal.

A very large number of passengers would have to be handled between surface and subway at any western terminus, and heavy west-end surface lines would have to be turned. It is highly desirable, therefore, to intercept west-end passenger traffic at some point less congested than Peel and St. Catherine Streets and where turning facilities for surface routes would be more commodious.

For this reason, and in order to afford west-end citizens additional benefits from the initial subway, it is proposed to continue west on St. Catherine Street to Atwater Avenue.

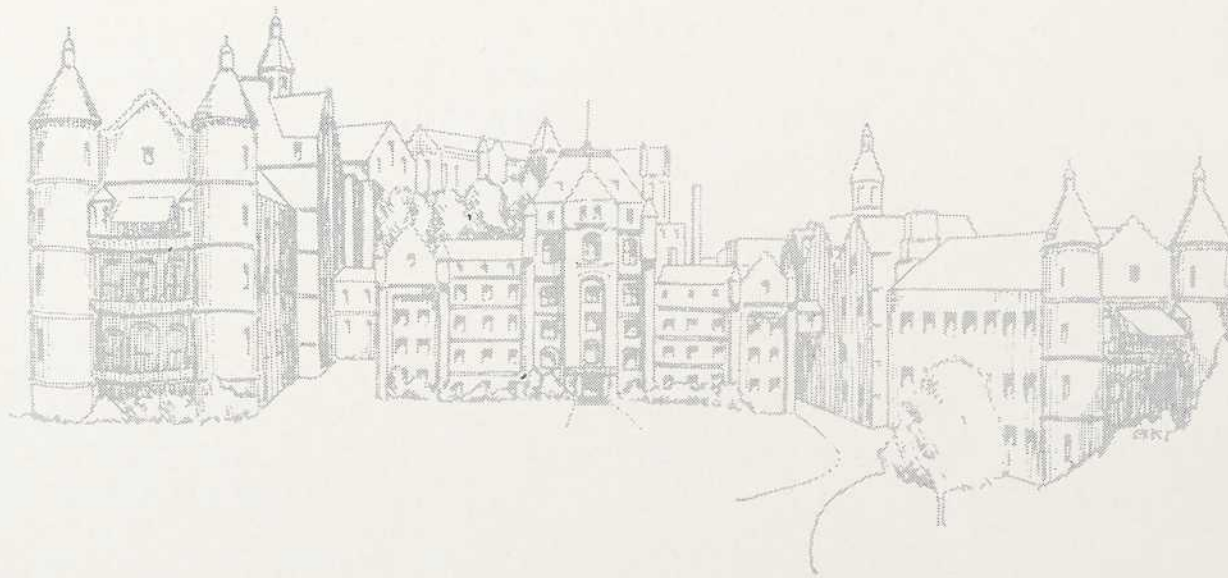
With this extension the subway would have a worthwhile influence on west-end travel. From counts of present east-west transit passengers crossing Atwater Avenue, it is calculated that 45,000 passengers per day would transfer to and from the subway at this terminal. In addition, passengers travelling to and from Verdun via Atwater Avenue, amounting to 34,000 per day, would use the subway east of Atwater Avenue.

Similarly, at Guy and St. Catherine Streets a fair proportion of the 49,000 passengers using Côte des Neiges Road services from the Snowdon area and Guy—Pointe St. Charles services from the south would make direct contact with the subway for the remainder of their journeys.

The total passenger-time saved is calculated to be more than 11,000 hours per day if rapid transit facilities are extended to include the section of St. Catherine Street between Peel Street and Atwater Avenue.

Furthermore, such a measure would remove from the surface streets the major part of all transit traffic in a congested part of the central area.

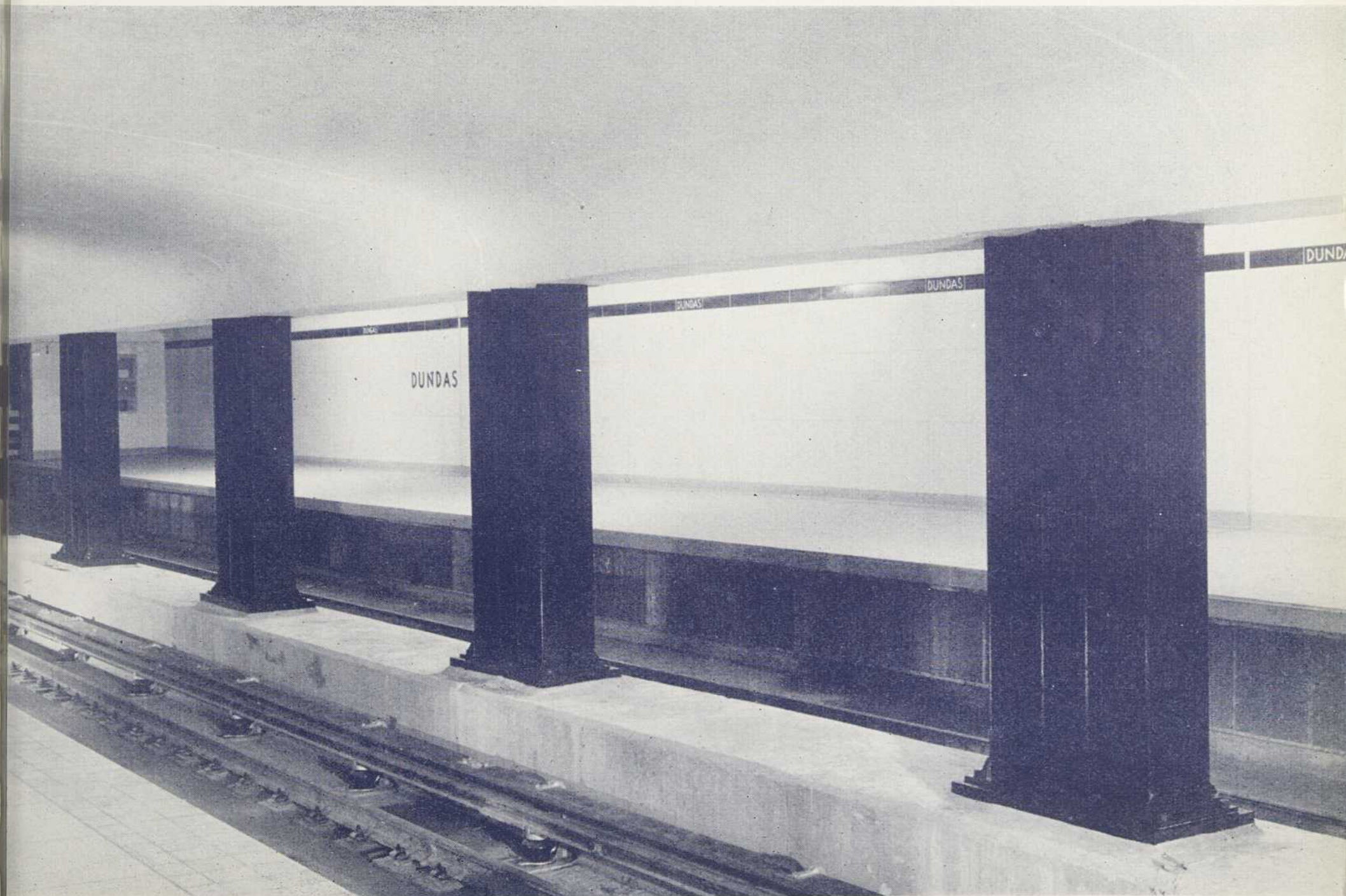
This section of subway, while it would be operated initially as part of the St. Denis Street subway route, would be, in reality, the first section of an east-west subway.





Partly Installed Station Finish — Toronto Subway

Side Platform Station Nearly Completed — Toronto Subway



CHAPTER IV

A COMPREHENSIVE SUBWAY SYSTEM

FACTORS REGARDING ITS LOCATION

A comprehensive rapid transit system with about 23 miles of route has been planned. See Exhibit 3. It is contemplated that some outer portions may be built, in part, as electric railroads in private rights-of-way with landscaped side slopes and with grade separations at certain intersections with streets, highways, or other railroads.

The recommended system is so extensive that almost every resident of the metropolitan area could utilize at least a portion of the subway for his daily travel requirements. Many trips would be completed entirely on the subway system while others would involve use of feeder buses serving convenient transfer terminals or stations. Of the estimated 1,750,000 population in the inner metropolitan area (1971) 63.4 percent would be within one mile of a subway station.

The extent of the system and the choice of routes were governed by many factors. One was the locations of heavy concentrations of people, which are seen at a glance by reference to Exhibit 3. Another consideration was the need for rapid transit to the outer portions of the metropolitan area. The potential time savings by use of rapid transit from these districts will reach very substantial values. Another determinant in selecting subway routes was the anticipated direction and density of future population growth. Finally, thought had to be given to the opportunities afforded by existing and possible future streets and highways for a system of feeder bus routes integrated with and complementing the system.

LOCATION AND EXTENT

For the benefit of the reader unacquainted with Montreal, it should be explained that in local usage "north" is at right angles to and away from the St. Lawrence River. Actually, this direction is only about 30 degrees off due west. The local usage in regard to directions will be used throughout this report.

The recommended subway pattern consists of a number of elements, first of which is the north-south section along St. Denis Street from a terminal immediately north of Crémazie Boulevard, to Craig Street. Stations would be located at Legendre Street, the northern terminal, and at Crémazie Boulevard, Villeray Street, Jean Talon Street, Beaubien Street, de Fleurimont Street, St. Joseph Boulevard, Mount Royal Avenue, Cherrier Street, and at St. Catherine Street.

The St. Denis Street subway, passing through heavily populated districts east of the Mountain, would serve the north-central section of the City; passengers being distributed laterally by buses operating east and west from the various stations. The northern terminal would act as a convenient surface distribution point of residents of Ahuntsic, Bordeaux, and areas bordering on the Rivière des Prairies.

Coupled with this portion of the subway system is the downtown section, with stations at Champ-de-Mars, Place d'Armes, and Victoria Square, and thence to Dominion Square.

As previously described in Chapter III, these sections of the subway network comprise the major part of the initial construction recommended.

Another component of the comprehensive plan consists of an east-west route extending from Viau Street on the east to Girouard Avenue on the west, a total length of 6.56 miles. The subway would follow Ontario Street from Viau Street to de Lorimier Avenue, then swing south and follow St. Catherine Street to Atwater Avenue. From Atwater Avenue to Girouard Avenue it would follow Sherbrooke Street. Stations would be located at Viau Street, Pie IX Boulevard, Davidson Street, Harbour Street, de Lorimier Avenue (Stadium), Amherst Street, St. Denis Street, St. Lawrence Boulevard, Phillips Square, Peel Street, Guy Street, Atwater Avenue, Kensington Avenue, Victoria Avenue, and Girouard Avenue.

It would constitute an east-west route through the heart of the city with direct access to most of the central shopping district; it would also serve hotels, railway stations, and offices in the mid-town section.

This subway would serve residential areas in the east and west parts of the city, as well as the east-end industrial area. The eastern terminal on Viau Street would serve as a surface distribution point for persons travelling to the extreme eastern part of Montreal and the Towns of Montreal East and Pointe-aux-Trembles. Contact would be made with surface transportation to South Shore areas, via Jacques Cartier Bridge, at the Ontario—de Lorimier Station.

On the west, this section of subway would touch a large residential area of Montreal and Westmount, and would afford convenient surface distribution to the southwest part of the City.

As described in the preceding chapter, a portion of this east-west route, namely on St. Catherine Street between Peel Street and Atwater Avenue, would be included in the initial stage of construction. Under the first stage of construction, provision has been made for connecting the future east-west subway with the initial subway just west of the intersection of St. Catherine and Peel Streets. When the portion of the east-west subway east of Peel Street is later constructed, there will, therefore, be no disturbance to operations in the initial subway. Provision has also been made for the future continuation of the initial subway structure northward under Peel Street and passing under the east-west line, to provide track facilities necessary for reversing the trains using the initial subway. After this future work has been completed, the curve from Dominion Square station into St. Catherine Street west, will serve only to transfer rolling stock from one line to the other.

A further component of a comprehensive subway system would be a north-east route along Frontenac and Iberville Streets to Jean Talon Street and then eastward to Pie IX Boulevard, a total length of 3.90 miles. This route would serve the northeastern part of the City and the Towns of St. Michel and Montreal North; these, and adjacent areas, would be brought into direct contact with the subway by surface bus routes.

Stations would be located at Sherbrooke Street, St. Joseph Boulevard, Rosemont Boulevard, Bélanger Street, and on Jean Talon Street at Montée St. Michel, and at Pie IX Boulevard.

Similarly a north-west route would be located along Girouard Avenue, or vicinity, and Décarie Boulevard to Church Avenue in Ville St. Laurent, a length of 4.42 miles. This route would serve the northern part of Notre-Dame de Grâce and the Towns of Hampstead and Côte St. Luc, as well as the

industrial and residential areas north of Queen Mary Road and in the Towns of Mt. Royal and St. Laurent.

Stations would be located at Sherbrooke Street, Terrebonne—Côte St. Luc, Queen Mary Road, Garland, Namur Street (future), Côte de Liesse, and Church Avenue.

The schedule for completing the comprehensive system would depend on future population growth, financial considerations, and many other factors.

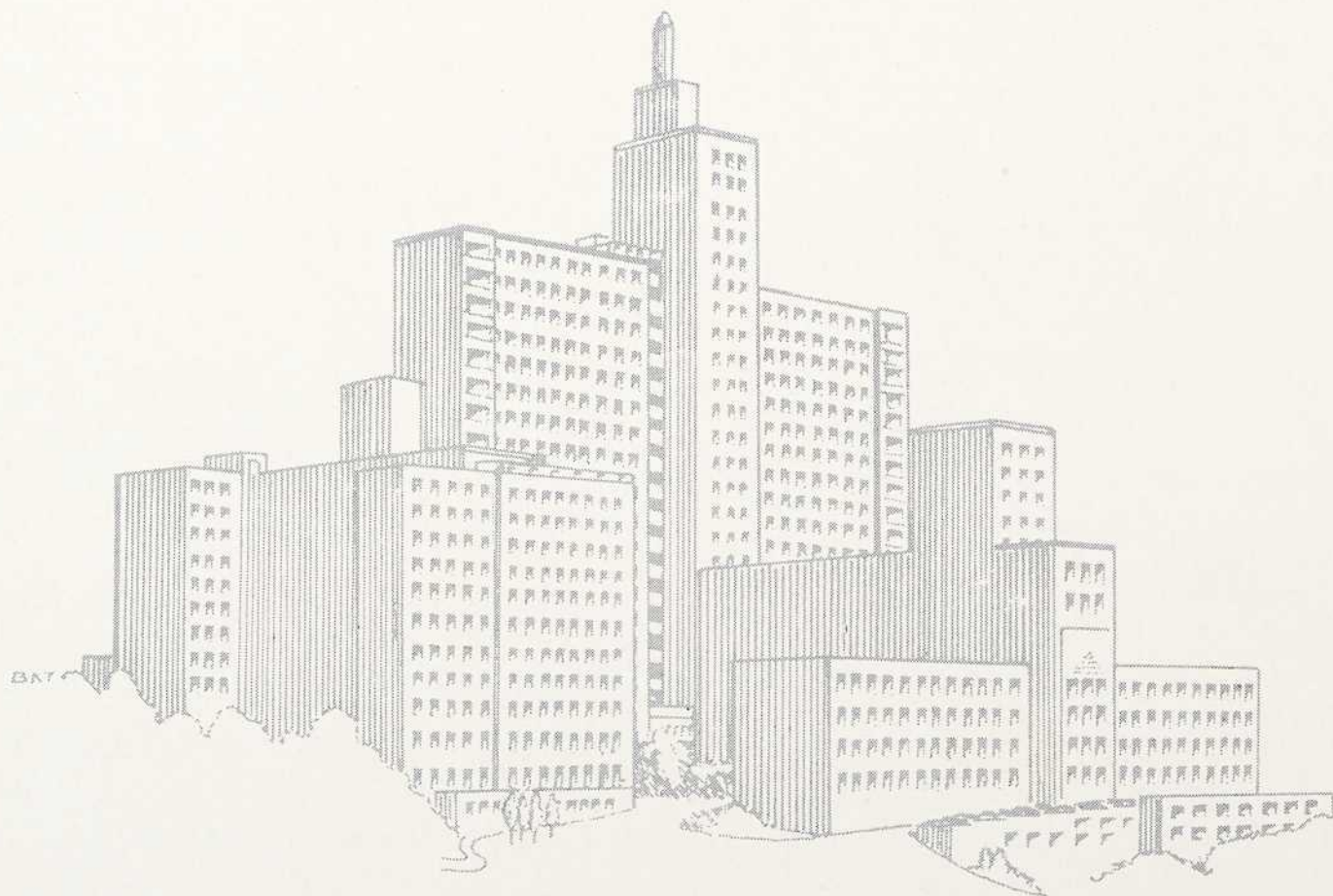
When all parts of the recommended system are completed, the city will be integrated by a system of subways serving almost all parts of the metropolitan area. Preliminary plans contemplate the building of this system in stages, with each stage coordinated with all previously constructed parts.

Complete studies and detailed plans (see Book of Plans) have been made of the initial portion of subway described in Chapter III.

As to the various extensions to complete the comprehensive system just described, sufficient data have been obtained and preliminary studies made to establish the feasibility of the entire project.

COORDINATION OF SURFACE LINES

A possible pattern of surface bus routes integrated with the subway system is also shown on Exhibit 3. The changes from the existing surface system would be made gradually as the various components of the subway network are constructed. The surface system as shown must be considered as tentative, as future changes in street and highway patterns and other unforeseen circumstances could conceivably alter this pattern to some extent.



CHAPTER V

DESIGN AND CONSTRUCTION OF INITIAL SUBWAY

CONSTRUCTION METHODS ELSEWHERE

After completion of a functional plan for subways and selection of a portion of this system for initial construction, it became necessary to explore physical problems in considerable detail. Alternate studies were made, for example, covering subways built at high-level and at low-level and by both the cut-and-cover and by tunnel methods.

Subway construction in each city is a special problem. The design should take advantage of favorable conditions and avoid situations which may involve unnecessary delays, expense or inconvenience to surface traffic. In cities such as Montreal, with a variety of subsurface conditions, various portions of the system are likely to require different construction methods.

In London, essentially all subways have been built by the tunnelling method because of subsurface conditions favoring such construction. In New York all subways are at relatively high-level to minimize the vertical distance between station platforms and the street surface and also to permit direct access into buildings adjoining the stations. For the most part New York subways were built by the cut-and-cover method, except for river crossings and other special instances where tunnelling methods were necessary. The subways in Philadelphia were built largely at high-level by the cut-and-cover method except where tunnelling was required by river crossings. The clay soil underlying Chicago made tunnelling at low-level the most economical type of construction.

In Toronto, consideration was given to the relative advantages of a deep tube system and a high-level subway before the rail grade was determined. It was found that tunnel construction



Center Platform Station — Chicago Subway

would have involved greater cost. While tunnel construction would eliminate some of the disturbance to utilities and to the surface streets during construction, the surface excavation for subway stations—generally at intersections of greatest traffic and underground utility congestion—would be required in any event. It was concluded, therefore, that any minor gain in convenience during a few months of initial construction would be more than offset by the increased convenience to the passengers through location of platforms as close as possible to the sidewalks. This shorter climb, furthermore, would benefit the passengers for all time.

METHODS OF CONSTRUCTION IN MONTREAL

The two factors given most weight in the Montreal studies were relative economy and convenience to passengers. Numerous estimates of cost were made on the basis of alternate designs. Factors considered included the ground water situation, soil conditions, presence of rock suitable for tunnelling, and the existence of utilities, particularly large trunk sewers.

Considerable subsurface information was available through soil test borings made by the Department of Public Works of the City of Montreal. These borings had been made in connection with the report of 1949 by the Board of Research on Traffic and Transportation Problems. Data were also collected from records made during the construction of various buildings along the proposed route and from information gathered by the railway companies.

The data as thus assembled were not adequate for the determination of the type of structure, the proper grade line, and the methods of construction to provide the most economical and efficient rapid transit subway. It was decided, therefore, to make 89 additional test borings and to dig 8 open test pits. These gave very comprehensive information on the composition of the soils, the level of the subsurface water table, and the approximate elevation of the rock line along the entire length of the initial subway.

Rock core, Shelby tube, and split spoon samples of the materials recovered from the various borings were submitted to Mr. Jacques E. Hurtubise, M. Sc. A., Ing. P., M.E.I.C., Professor at École Polytechnique, for laboratory analysis. The soil sample analyses included visual classification, grain size analysis, water content, and, where applicable, unconfined compression tests, consistency limits, and unit wet weights. Rock cores were identified, classified, and the angle of stratification recorded.

The Commission is indebted to Mr. Robert F. Legget, Director, and Mr. W. R. Schriever (Soils Mechanics Section), Division of Building Research, of the National Research Council, who worked in close cooperation with the Commission's engineers during the soils investigation program.

The open test pits were located in or near the central district, where preliminary information indicated the most troublesome subsoil conditions would be encountered. These test pits were excavated from the street surface either to bed rock or to elevations well below any feasible subway invert grade. They were located as follows:

St. Louis Square (St. Denis Street)

Front of École Polytechnique (St. Denis Street)

Viger Square (St. Denis and Craig Streets)

Champ-de-Mars (between Craig and St. James Streets)

Place d'Armes (St. James Street)

Victoria Square (between St. James and Craig Streets)

Dominion Square (north of Dorchester Street)

Western Square (Atwater Avenue and St. Catherine Street West)

During the excavation of the open test pits at Victoria Square and at Viger Square it was found that the subsurface water table was at or close to elevation 35.0 (Mean Sea Level Datum). This elevation is above the invert of the subway in its highest possible location. A very comprehensive series of water pumping tests were conducted, therefore, at the test pit in Victoria Square. The purpose of these tests was to learn if the level of the water could be lowered during construction operations at a reasonable cost and without disturbance to adjacent buildings.

At this location 8 well points were installed in the pit with their points varying in elevation from 13.8 to 15.2. These points were connected into a common header and were pumped 24 hours per day for 8 days during which period the level of the water in the pit was lowered from elevation 35.0 to elevation 26.4. During this same period the level of the water in a test boring approximately 82 feet southwest of the pit was lowered from elevation 35.9 to elevation 30.5.

When the level of the water in the pit had stabilized at elevation 26.4, five additional points were driven within the pit to elevations varying from 5.4 to 8.9. When all 13 of these points were pumped simultaneously, together with two 175 gallons per minute sump pumps, the water was lowered to elevation 23.6. Lowering the water table to this elevation would permit construction of the subway in the dry by cut-and-cover methods. While the test was in operation it was found that the level of the water in a test boring some 700 feet west of the test pit was lowered 2 feet.

During the period of the entire test, 37 days, the discharge from the pit through the wellpoint system and the sump pumps averaged 216 gallons per minute. This low volume indicates the feasibility of controlling the ground-water situation by standard practices.

Pages 40 to 47 show soils data obtained from two of the test pits.

A separate volume entitled "Appendix C, Subsurface Investigations," has been published which contains in detail the findings at all test borings, test pits, and the pumping test at Victoria Square.

The subsurface information obtained made it possible to establish the proper alignment and grade for the most economical construction of the subway. It was determined that the most feasible method of construction for that portion of the initial subway project from Atwater Avenue on the west to the intersection of Ontario and St. Denis streets on the east would be by cut-and-cover methods. The invert of the subway could be located above the ground water table throughout this entire area, except for a section about 2000 feet in length extending from Inspector Street to McGill Street and for a second section less than 1000 feet in length in the vicinity of Craig and St. Denis Streets, where the subway would pass under Craig Street. Throughout this lower section of the project the subsoil above the ground water table consists largely of sand, gravel, boulders, and some silt. This would seem to eliminate tunnel construction for a rapid transit subway in this area as a practical and economical method. On the other hand, the condition disclosed the need for raising the grade of the subway to the highest possible level in order to reduce the amount of pumping

TABLE 4
RECORD OF SUBSURFACE WATER TABLE ELEVATIONS

TEST PIT A

Western Square — Intersection of St. Catherine Street and Atwater Avenue

<u>Date of Reading</u>		<u>Elevation Mean Sea Level</u>	<u>Date of Reading</u>		<u>Elevation Mean Sea Level</u>
December	17, 1951	113.9	June	16, 1952	114.1
January	9, 1952	114.1	June	30, 1952	114.4
January	14, 1952	113.8	July	14, 1952	114.9
January	28, 1952	114.7	August	11, 1952	115.4
February	25, 1952	113.7	October	8, 1952	115.8
April	7, 1952	115.6	October	21, 1952	114.5
April	21, 1952	113.6	November	3, 1952	115.6
May	5, 1952	113.7	December	23, 1952	114.7
May	19, 1952	113.6	February	23, 1953	115.2
June	2, 1952	113.8	April	15, 1953	114.4

TEST PIT C

Victoria Square — Between Craig Street and St. James Street

<u>Date of Reading</u>		<u>Elevation Mean Sea Level</u>	<u>Date of Reading</u>		<u>Elevation Mean Sea Level</u>
January	16, 1952	35.0	June	30, 1952	35.4
January	24, 1952	34.3	July	14, 1952	35.1
January	30, 1952	34.6	July	28, 1952	35.8
February	4, 1952	35.0	August	11, 1952	34.9
February	25, 1952	35.3	September	8, 1952	34.4
April	21, 1952	33.9	September	23, 1952	34.9
May	5, 1952	35.4	November	3, 1952	34.9
May	19, 1952	35.1	December	23, 1952	34.9
June	2, 1952	34.9	February	23, 1953	34.9
			May	12, 1953	34.9

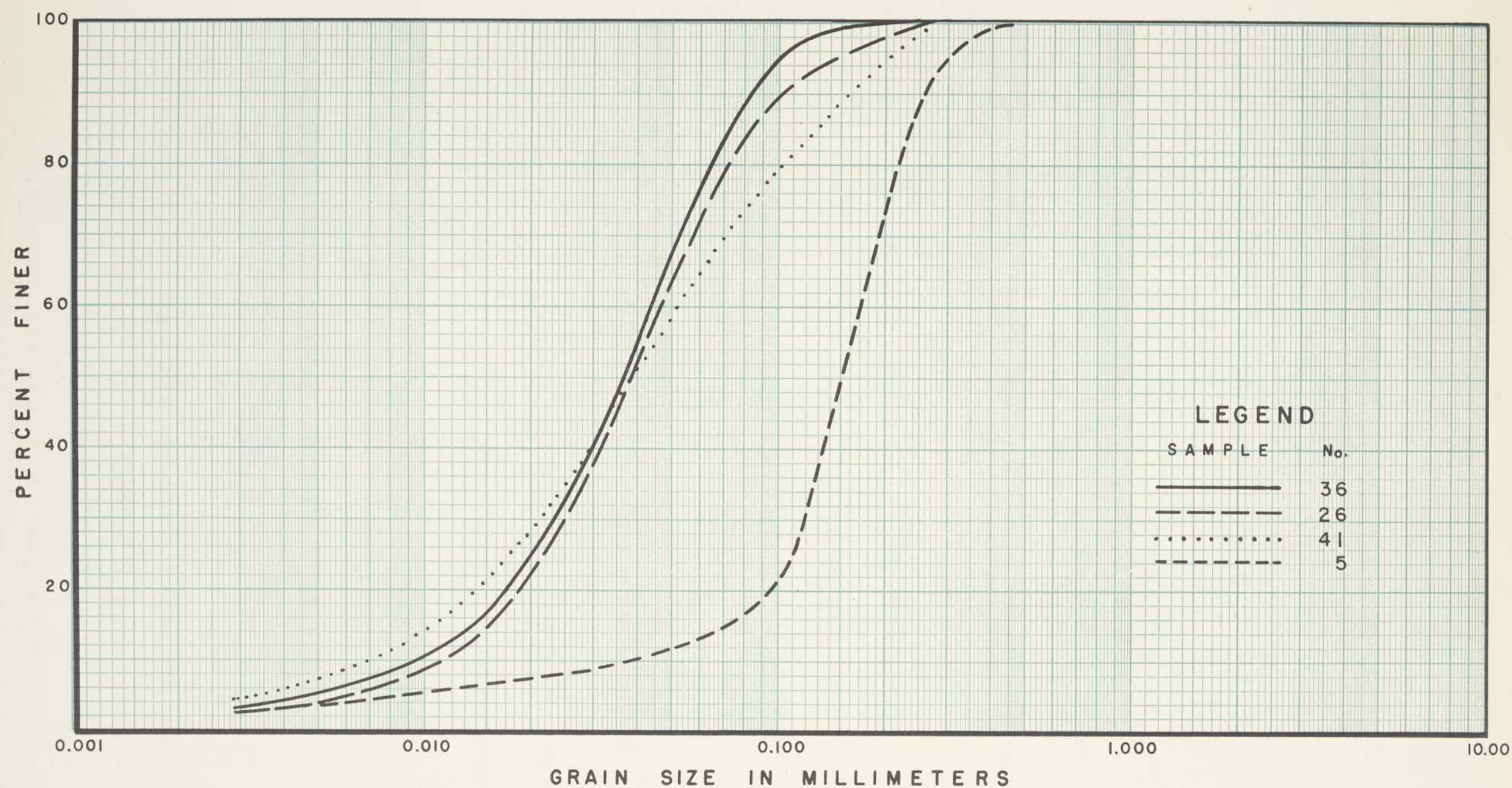
Note: For complete record see Appendix C.

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GRAIN SIZE DISTRIBUTION CURVE

TEST PIT A

WESTERN SQUARE

MONTREAL TRANSPORTATION COMMISSION—JUNE 1953

THEORY OF THE TIDE

CHAPTER IV

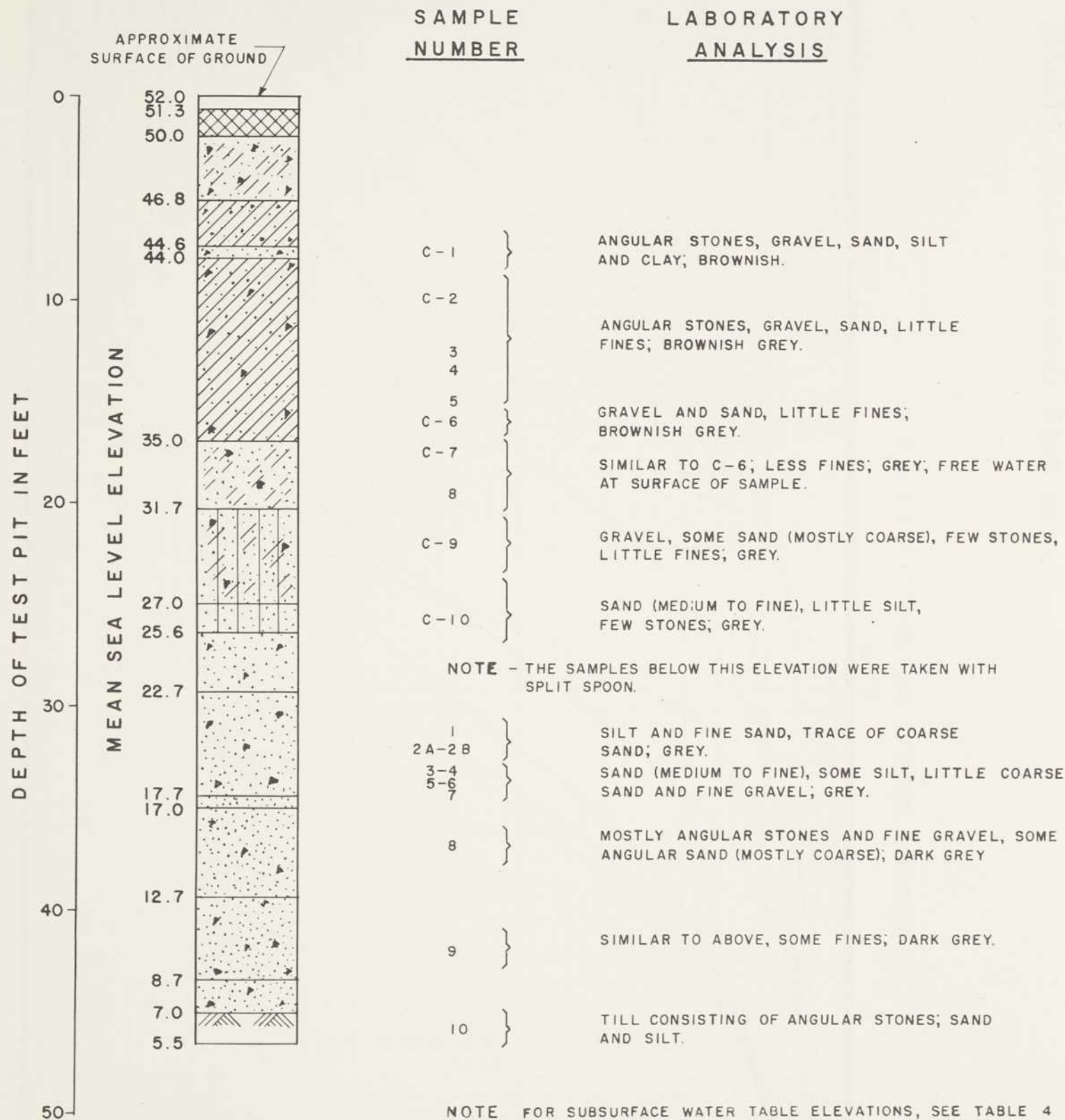
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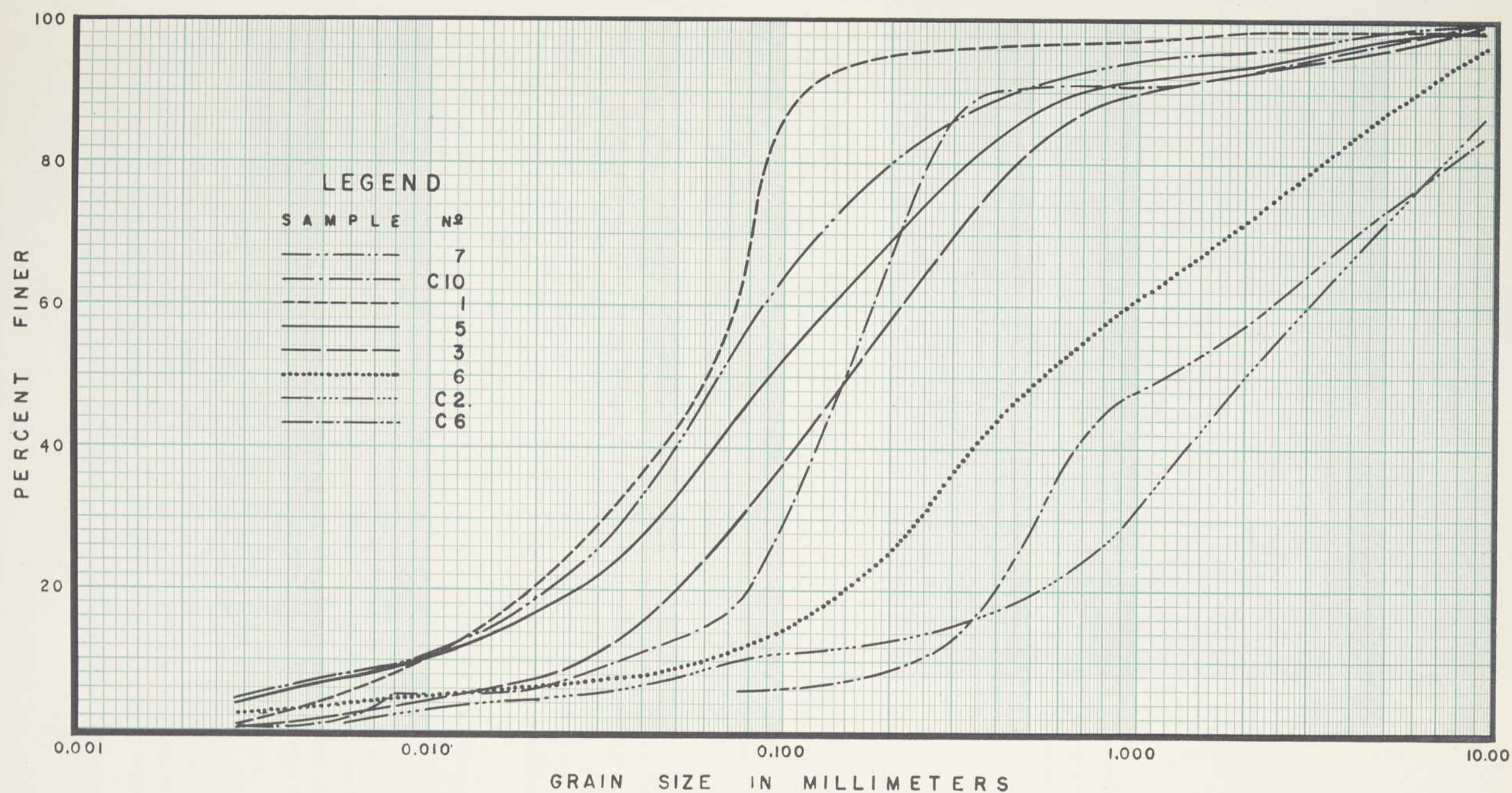


RECORD OF SOIL EXPLORATION

TEST PIT C

VICTORIA SQUARE

MONTREAL TRANSPORTATION COMMISSION-JUNE 1953



GRAIN SIZE DISTRIBUTION CURVE

TEST PIT C

VICTORIA SQUARE

MONTREAL TRANSPORTATION COMMISSION—JUNE 1953

RESEARCH AND DEVELOPMENT DIVISION

MEMORANDUM

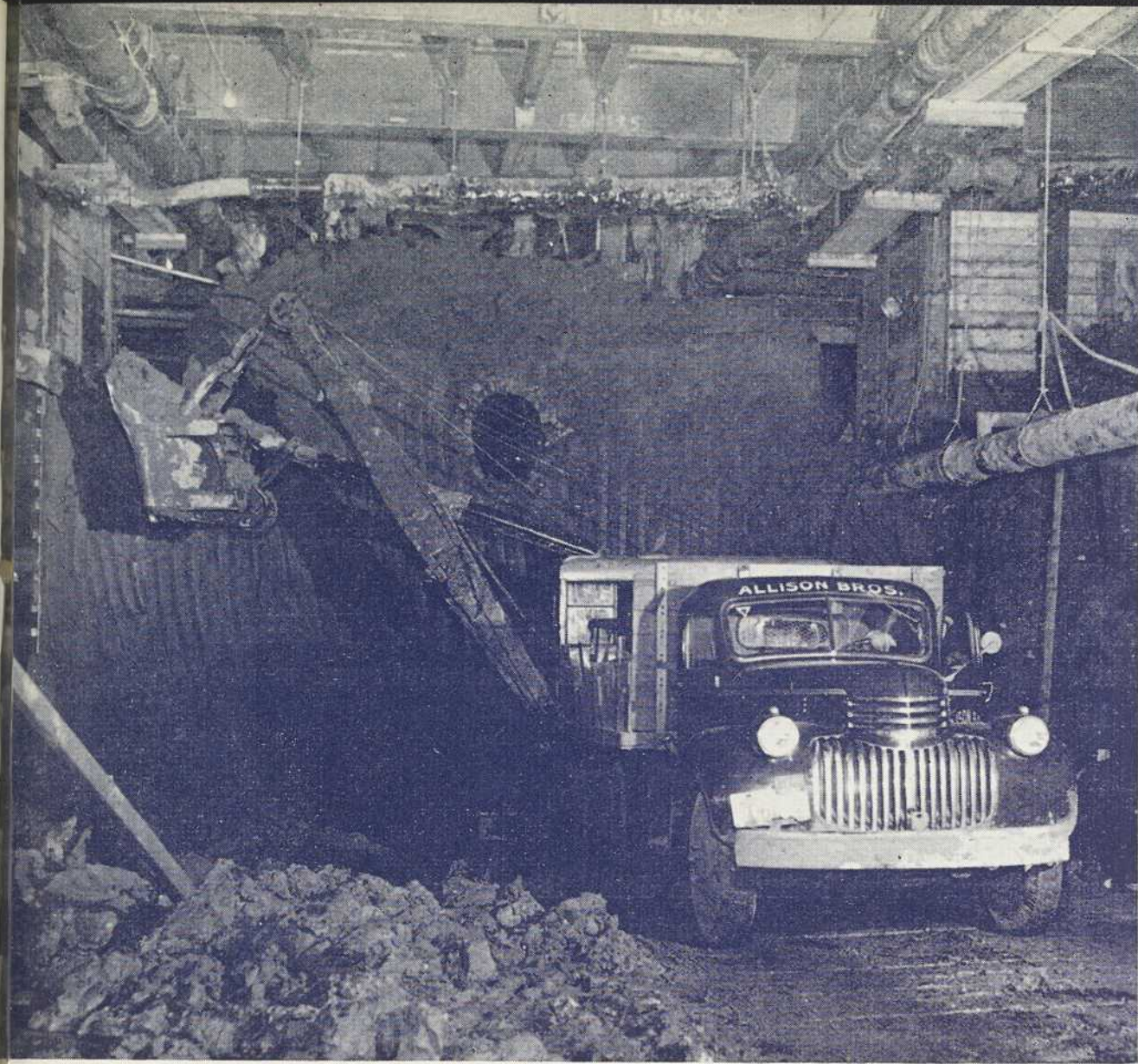
TO: MR. C.

FROM: MR. B.

SUBJECT: PROJECT X

DATE: 1/15/54





Excavation Under
Temporary Roadway
Toronto Subway

during construction and also to minimize the cost of underpinning the foundations of adjacent buildings. Except for the two specific locations noted above, namely the intersection of Craig and St. Denis Streets, and on St. James Street from McGill Street to Inspector Street, the subsoil conditions are satisfactory for subway construction along the recommended route between Ontario Street and the Atwater Terminal. In fact they are very favourable for cut-and-cover type of construction.

The main problem at St. Denis and Craig Streets and along St. James Street, between McGill Street and Inspector Street, is the lowering of the ground water table enough to permit construction to proceed. This can be accomplished through the use of wellpoint system or properly located deep wells. We consulted two construction experts neither of whom considered the dewatering of either of these areas as being a serious problem. In compiling the estimate adequate allowances have been made for the dewatering of these areas.

The possibility of constructing this section of the subway by tunnelling was also considered. It was found that the cost would greatly exceed that of constructing by cut-and-cover methods. This would be due mainly to the fact that all of the tunnelling would necessarily have to be done under compressed air pressure in order to prevent the water from entering the excavated area. In order to tunnel under air pressure, it would be necessary to lower the grade of the subway to prevent the loss of air through the working face of the shield. A comparison of the cost of the two methods indicated that tunnelling under air pressure would cost at least twice that of cut-and-cover type construction.

On St. Denis Street, between Ontario and Cherrier Streets, the soil stratum in which the tunnel will be built was found to be boulder till overlaid by two strata of silt and clay. Since the grade of the subway would lie from 38 feet to 51 feet below the surface of the street, it was found more economical to construct this section as two single-track tunnels in earth rather than by cut-and-cover methods.

Economical construction by cut-and-cover methods is indicated from the south end of the Cherrier Station to a point approximately midway between Marie-Anne Street and Mt. Royal Avenue.

Since the rock line approaches quite close to the surface at chainage station 151+00 north of Marie-Anne, construction of two independent tunnels through rock from this location to Crémazie Boulevard proves to be the most economical solution. The cores from the test borings indicate a crystalline limestone with a few small shale lenses, suitable for tunnelling.

Since the rock line recedes from the surface north of Crémazie Boulevard, it again becomes more economical to employ the cut-and-cover method of construction from the south end of the Crémazie Station to the portal in the Youville Yard area.

CONSTRUCTION PLANS

A complete set of plans has been prepared which indicates in detail the various types of construction that are considered to be most advantageous and economical under existing conditions. The plans, 111 in number, have been reproduced and bound in a separate volume.

These plans consist of general, as well as detailed, plan and profile drawings indicating the proposed route and grades for the initial subway; locations of stations, ventilation shafts, pumping stations, and electrical facilities; and other pertinent information. Structural drawings include, among others, those showing in detail the open cut (cut-and-cover), earth tunnel, and rock tunnel sections (both at and between stations); ventilation shafts and pumping stations; reinforcing and structural steel details; and details of membrane waterproofing for cut-and-cover type construction.

Also included are plans and sectional views of each of the 14 stations and the 2 terminals; details of side and island platforms; typical installations for ventilating fans and drainage pumps; typical diagrammatic layouts for electrical power and lighting systems; details of track installation; and plans indicating the proposed relocation of sewers.

These general plans, although definite, do not, of course, include all the detailed plans necessary for the execution of the project, but contract plans could be prepared from them whenever it is decided to proceed with subway construction.

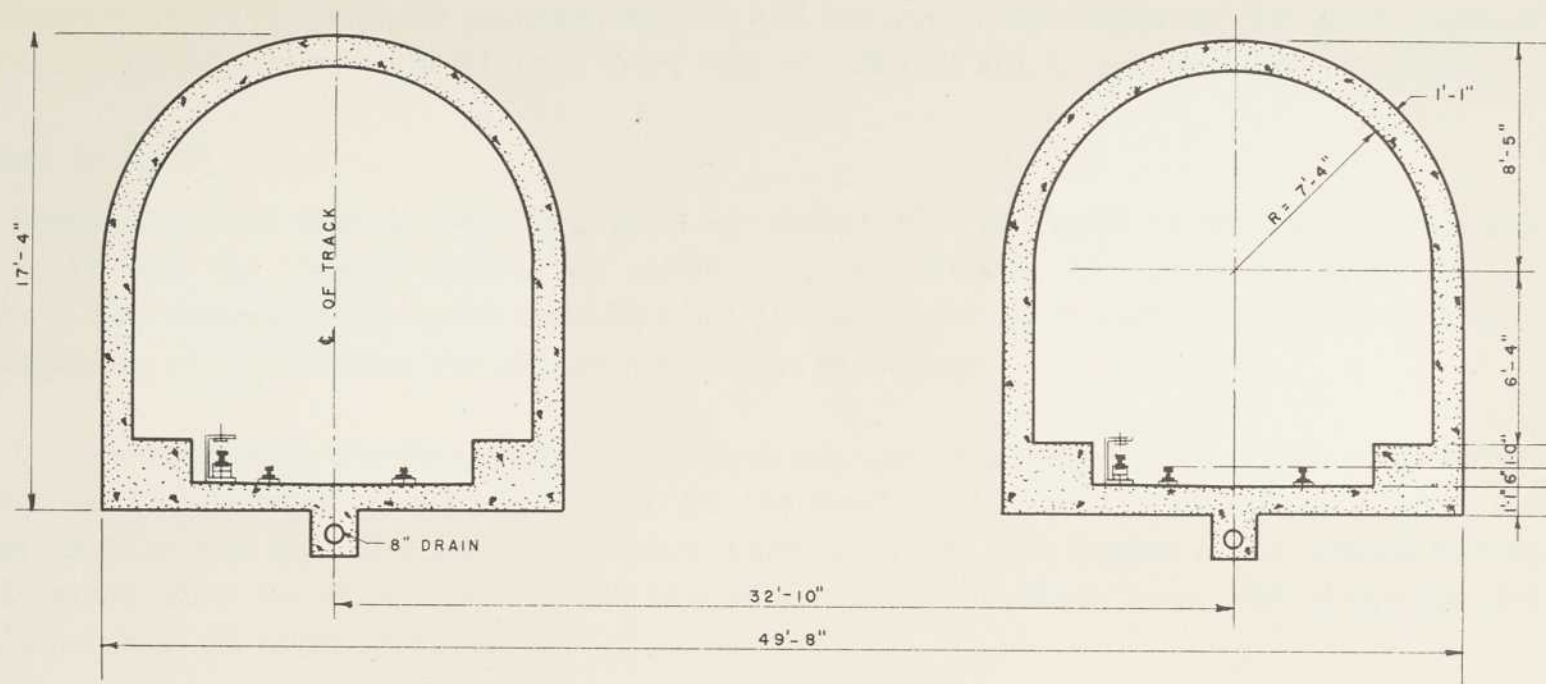
DESCRIPTION OF CONSTRUCTION METHODS

Tunnel in Rock

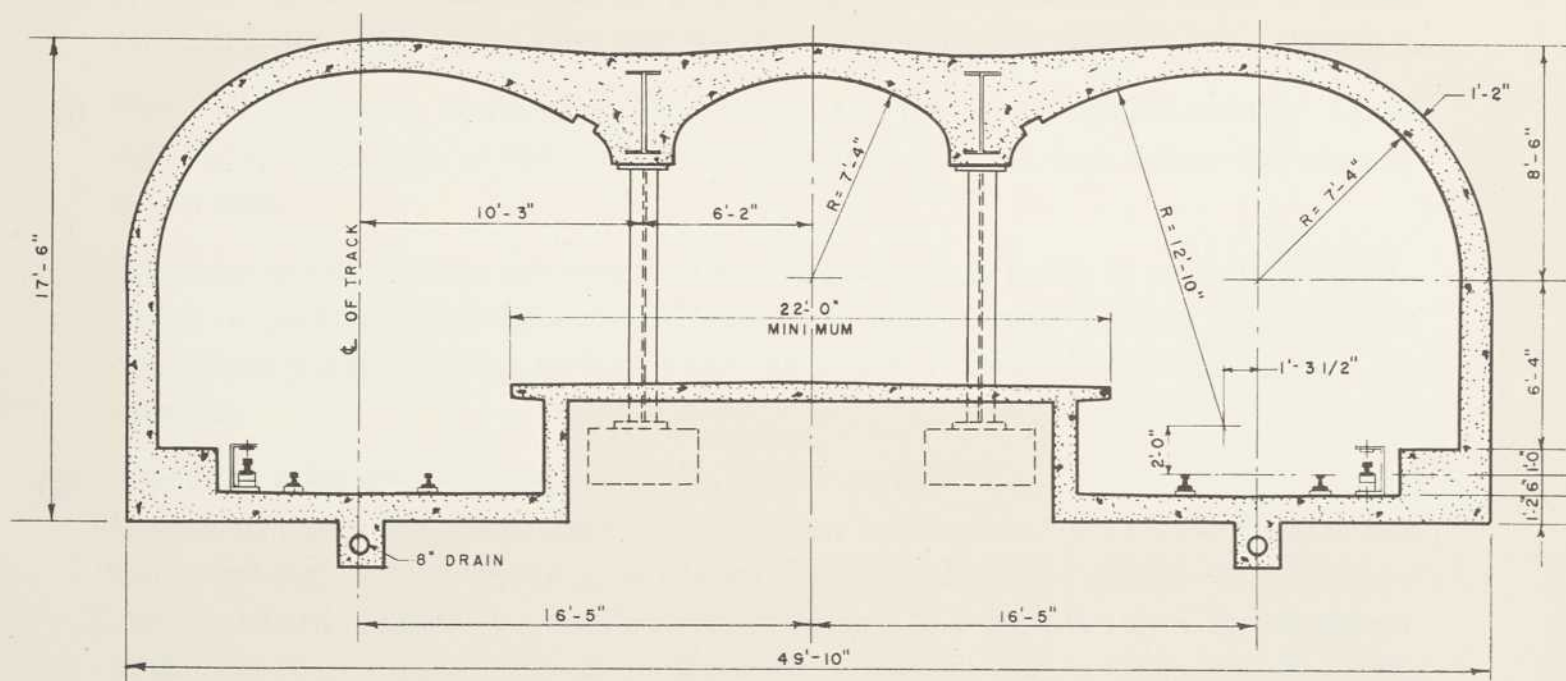
Rock tunnelling is recommended from chainage station 151+00, north of Marie-Anne Street, to chainage station 317+42, south of Crémazie Boulevard, (16,642 lineal feet). Shafts will be needed under this plan to permit removal of the excavated material, as well as for receiving concrete and other construction materials. Such shafts can readily be located where station mezzanines will be later constructed by cut-and-cover methods.

The separate single-track tubes will be on 32-foot 10-inch centres, thus permitting the construction of stations with island platforms which in turn would be served by stairways and escalators from the mezzanine. See Plate 5.

Prior to the selection of separate single-track tubes, full consideration was given to the possible



SECTION BETWEEN STATIONS



SECTION AT STATIONS

TYPICAL CONSTRUCTION IN ROCK TUNNEL



FIGURE 1. SECTION OF A TYPICAL CONSTRUCTION IN ROCK TUNNEL

use of a single two-track tube. This scheme was discarded because of the cost of the additional escalators required to serve side platform stations and because of the additional cost of the heavier reinforced concrete lining required for a single tube of sufficient size to accommodate two tracks.

Tunnel in Earth

Samples indicate that the soils from chainage station 104+50 (north of Ontario) to chainage station 117+05 (at Cherrier Street) are suitable for tunnelling in free air or by cut-and-cover methods. The subway invert varies from 38 to 51 feet below the street surface within these limits. A comparison of cost between the two methods favors tunnelling.

It is recommended, therefore, that twin single-track tunnels be constructed within these limits. It will not be necessary to construct shafts for the disposition of excavated materials since the entire length of this type of construction is only 1,255 lineal feet. The centres of the tunnels will be 18'-2" apart while the station at Cherrier will be of the side platform type, with stairways and escalators from the mezzanine area.

Open Cut (Cut-and-Cover Method)

Over the remaining portion of the proposed route it has been found much more economical to use the open cut method of construction. See Plate 6. This method, known also as the cut-and-cover type of construction, is briefly described as follows:

- (a) Narrow trenches are dug along the outside lines of the structure in order to expose all buried utilities, so that they will not be damaged during pile driving operations.
- (b) Steel "H" columns (soldier or king piles) are driven on approximately 6-foot centres on each side of the structure, extending about 8 feet below the subway invert slab.
- (c) Streetcar tracks, if any, are removed and excavation is made to a depth of about 8 feet to permit installation of the temporary deck beams. During this phase of operations public utilities such as water lines, sewer lines, electric cables, etc., are exposed.
- (d) The steel piles are then cut off at grade and capped, steel beams of the required section to carry the street load are placed on approximately 12-foot centres, and the temporary timber roadway is placed. These timbers are placed longitudinally and usually of a length to span three beams. Joints in the timber deck are staggered. If the streetcar tracks are to be replaced, cross ties are laid in the track area, rails laid and spiked in place, and 4-inch longitudinal deck timber placed over the ties. In this stage utilities such as water lines, electric cables, etc., previously exposed, are suspended from the deck beams permitting maintenance of service during the construction period.
- (e) Traffic is resumed while the balance of the excavation and construction is carried on beneath the temporary decking.
As the excavation operation is carried on beneath the temporary deck, timber lagging is placed between the "H" piles to eliminate settlement of the adjacent earth or damage to adjoining buildings.

- (f) After construction of the main subway structure has been completed the space between the top of the structure and the original street level is backfilled. The material is usually sand which is compacted to eliminate future settlement.
- (g) As soon as the backfilling reaches the bottom of the temporary steel beams, the deck is removed, the beams are taken out, piles are cut off above the top of the structure, backfilling is completed, utilities are replaced, and the roadway is reconstructed.

To minimize inconvenience to the public, the area opened at any one time will be limited by the specifications.

DESIGN SPECIFICATIONS

The proposed design specifications for structural steel, reinforcing steel, and concrete conform with the American Railway Engineering Association standards. These were modified where necessary to conform with the building code of the City of Montreal (By-law No. 1900); the National Building Code; and a circular letter issued February 8, 1952, by the Building Code Committee of the City of Montreal.

Design Loads

Members were proportioned for the combination of dead loads, live loads, impact, temperature forces, centrifugal forces, longitudinal forces and lateral forces, giving maximum sections.

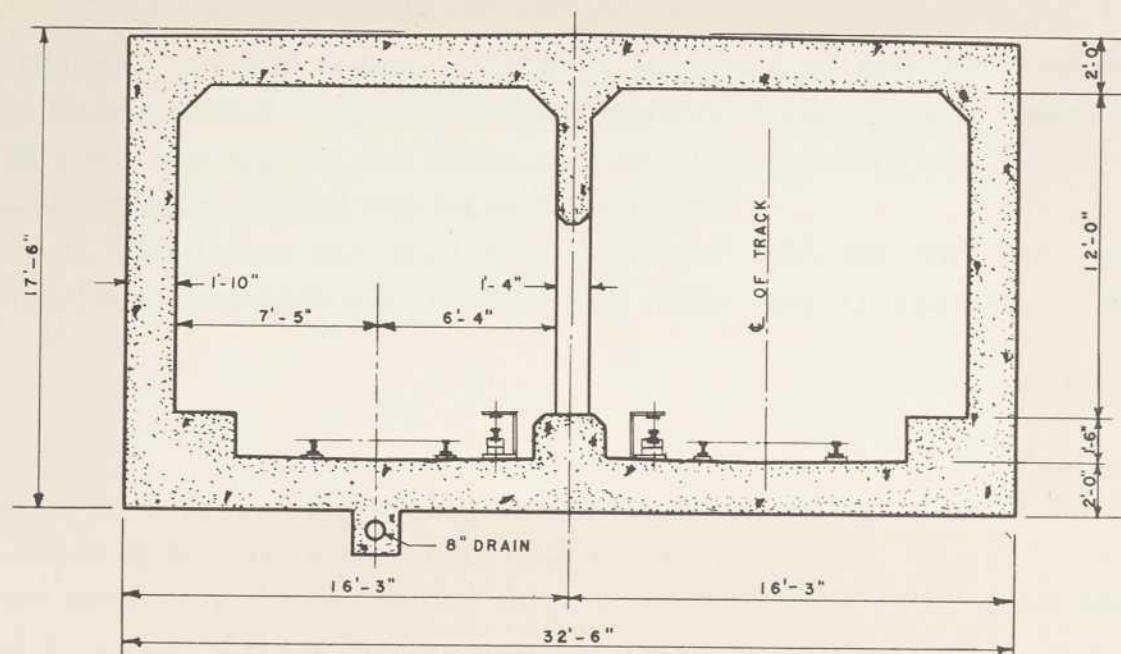
In proportioning the various parts of the structure, provision was made for stresses corresponding to the following groups of applied loads.

- Group A — Dead load, live load and impact; for which the unit stresses specified were used.
- Group B — Lateral forces, longitudinal forces, and temperature effects, jointly or separately; also at unit stresses specified.
- Group C — Any one item or more in Group A, combined with any one or all items in Group B; for which the unit stresses specified may be increased by twenty-five per cent.

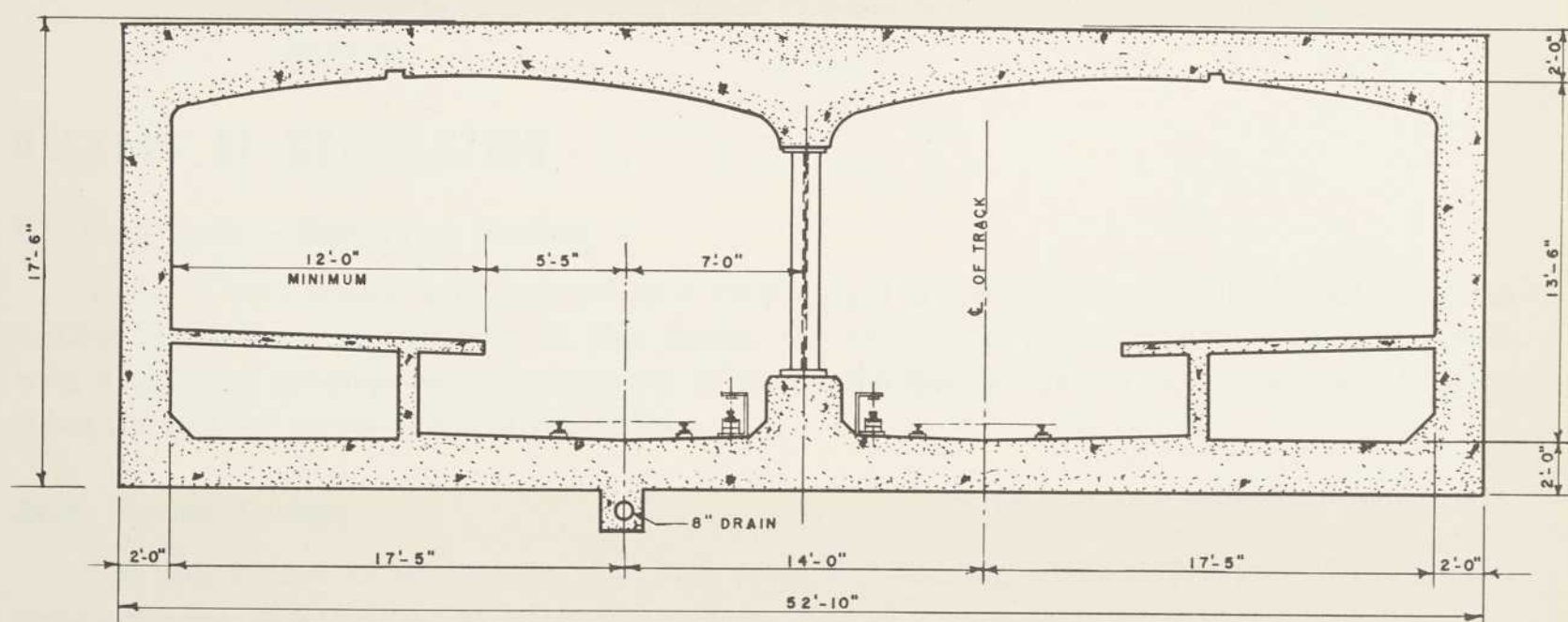
The dead load consists of the entire weight of the structure together with the weight of the superimposed earth including the pavement and in some instances streetcar track. When under property which has to be supported wholly or partly by the subway structure, provisions were made for such loads.

Case I

Live loads on the roadways of the streets above the subway were considered as being those designated under the American Association of State Highway Officials under specification H20-16-44 using a truck train loading, which considers that four-fifths of the total truck load is carried on the rear axle and the remaining one-fifth of the load is carried on the front axle. Each truck was considered as occupying one lane of traffic 10 feet in width, and for the total loading it was considered that there would be a truck in each 10-foot lane of roadway within the curb limits.



SECTION BETWEEN STATIONS



SECTION AT STATIONS

TYPICAL CONSTRUCTION IN OPEN CUT



Case II

It was considered possible to have a train of streetcars on each track consisting of two or more 50-ton 40-foot double truck cars coupled together. Each axle was considered as having a loading of 25 kips. Axle spacing was taken as 5 feet-20 feet-5 feet and the distance between adjacent axles on two cars coupled was taken to be 10 feet.

When it was found that the dead load combined with the live load under Case I, exceeded the dead load combined with the live load under Case II, calculations were based on Case I.

Case III

A uniform live load of 300 pounds per square foot governed when it produced greater stresses than either of the above mentioned loads.

Loads were assumed to be distributed through the earth at a ratio of one-half to a minimum depth of 3 feet. At this depth the distribution area was considered as being 6 by 6 feet with point applications of the load at the surface of the pavement.

Stresses in the subway structure were calculated for the following combinations of loading:

- (1) Full vertical and longitudinal load;
- (2) Full vertical load, with full horizontal load on one side and half horizontal load on the other;
- (3) Full vertical load and half horizontal load on each side;
- (4) Interior hydrostatic load where such loading is a possibility;
- (5) Combination of (4) with either of the other cases to produce maximum stresses.

METHODS OF CALCULATION

Cut-and-Cover — Box Type Section

The box type section was designed as a simple rigid frame structure, using the Hardy-Cross method for moment distribution. In this design, the two tracks are separated by a center wall with 5 by 7-foot openings on 20-foot centres to permit the free circulation of air for ventilating the tubes through the piston action of the trains.

Rock Tunnel Section

The rock tunnel section, as well, has been conceived as a rigid frame. The roof of the station mezzanine has been designed as a flat slab and the floor as a continuous concrete T-beam.

When designing the tubes the bridging action of the rock was taken into consideration.

Rock cores recovered during test boring operations were examined and information was obtained from the Canadian National Railways concerning their findings during the construction of the Mt. Royal Tunnel. Based on the facts thus obtained, 13-inch reinforced concrete linings will be constructed where the tubes are tunnelled through rock. In addition to their structural function these linings will eliminate the seepage of water into the tubes.

All water seams encountered during excavation will be pressure grouted before the lining is placed in order to avoid hydrostatic pressure on freshly poured concrete.

Earth Tunnel Section

The analysis for the various loadings was by the method of column analogy.

Our studies indicate that a reinforced concrete lining 2 feet in thickness will be required for the twin, single-track tubes, together with a 3-foot 6-inch thick separating wall, and an invert slab 2 feet thick.

From laboratory analyses it was found that the angle of repose for most of the soils encountered was 32 degrees and this figure was used in determining the extent of underpinning required to prevent damage to adjacent structures by settlement or movement.

UNDERDRAINS

It is proposed to construct an 8-inch cast iron longitudinal drain under the invert slab of cut-and-cover type construction. Underdrains of 8-inch diameter cast iron pipe will be necessary under the invert slab of each tube in tunnel type construction. These will drain any seepage getting to the invert slab; rain and melted snow entering at stairways to the street; water from washing station platforms; and possible flooding from broken water mains. The water will be collected in side sumps at nine locations. At these points, two 750 gallons per minute electrically operated float controlled pumps, will be installed to raise the water into the permanent sewer system. One pump will normally be in operation, while the other will act as a stand-by unit.

REARRANGEMENT OF PUBLIC UTILITIES

Sewer Relocations

The subway would intercept several existing trunk and branch sewers where open cut (cut-and-cover) type of construction is recommended. In such instances it would be necessary to replace these existing sewers with new ones located outside of the limits of the subway structure and parallel thereto. In certain locations where it would be possible to rebuild a sewer above the structure, this has been recommended. During the construction period, temporary flumes would serve the properties on either side of the structure until such time as the final relocations could be completed.

In the following locations, it would be necessary to provide complete new sewers to by-pass the subway structure.

- (1) Corner of St. Catherine and Gladstone Streets to Atwater and Tupper Streets via Tupper.
- (2) On Stanley Street from St. Catherine to Dorchester Street.
- (3) On Peel Street between St. Catherine and Cypress Streets, in order to clear the north mezzanine of the Dominion Square Station.
- (4) The existing 4 by 6-foot and 6-foot trunk sewers on St. James Street would be combined into an 8 by 6-foot concrete box sewer, carried north on St. Cecile to St. Antoine Street under the subway structure and eastward on St. Antoine Street to a junction with the old sewers near the intersection of Little St. Antoine and Craig streets.

- (5) In order to clear the Victoria Square Station, it would be necessary to construct a multiple barrel inverted siphon under the structure at the intersection of McGill and St. James Streets and also to construct a new 6 by 6-foot concrete box sewer south of St. James to permit this sewer to continue to act as an overflow from the Craig Street trunk sewers. South of St. James this would also handle the sewerage from St. James Street, west of Place d'Armes Hill.
- (6) It would be necessary to relocate the 48-inch sewer connecting the Commissioner Street trunk sewer, through the Commissioner Street Pumping Station, to the Craig Street trunk sewer, from St. James to Craig Street under Place d'Armes Hill. This line is pumped during the winter months. This relocation would be required in order to clear the Place d'Armes Station.
- (7) In order to eliminate the necessity of an inverted siphon under the subway structure near the intersection of Craig and St. Denis Streets, a by-pass sewer 8 by 6 feet would be required from Gosford and Craig Streets, south on Gosford to Champ-de-Mars Street, extended to Berri Street, thence northward to a junction with the existing Craig Street trunk sewer.
- (8) The existing 5-foot trunk sewer on St. Catherine Street passes through the area required for the St. Catherine—de Montigny station and would also conflict with the future east-west subway on St. Catherine Street, east of St. Denis Street. We have, therefore, designed a by-pass of this trunk sewer which would solve this problem between Sanguinet and Amherst Streets. In order to maintain the gradient required for this gravity trunk sewer a new 5 by 5-foot concrete box sewer has been designed to flow south on Sanguinet Street, east on Dorchester Street, south on St. Denis Street, to Lagauchetière Street where it would cross over the subway structure, east to St. Hubert Street, north to Dorchester Street and thence to a junction with the present sewer at Amherst Street.
- (9) The existing 4 by 6-foot trunk sewer on Ontario Street would interfere with construction of the subway. It would not be advisable to lower the subway grade at this point because that would create an excessive operating grade north of Ontario Street. It would not be possible to raise the subway grade a sufficient amount to clear the sewer. A multiple barrel inverted siphon has been designed, therefore, for this location. The construction of a pumping station was seriously considered but was abandoned due to the initial cost as well as continuous future operating costs.
- (10) Existing 2 by 3-foot and 6-foot sewers on St. Denis Street north of Crémazie Boulevard have been proposed to be relocated on Berri Street from Crémazie Boulevard to Emile-Journault Street, and west to a junction with the present sewers at St. Denis Street north of the subway structure. The existing 6-foot sewer on St. Denis Street, north of Crémazie Boulevard, has been replaced in the proposed plans by a 5 by 6-foot concrete box sewer on Berri Street, and on Emile-Journault Street to a junction with the existing sewer at St. Denis Street and Emile-Journault Street.
- (11) The existing 42-inch sewer on Crémazie Boulevard that discharges into the 3-foot 6-inch sewer on Henri-Julien Street, has been relocated in the plans as a 4 by 3-foot box sewer on Berri and Emile-Journault Streets and thence along the subway structure to a junction with the existing sewer on Henri-Julien Street.

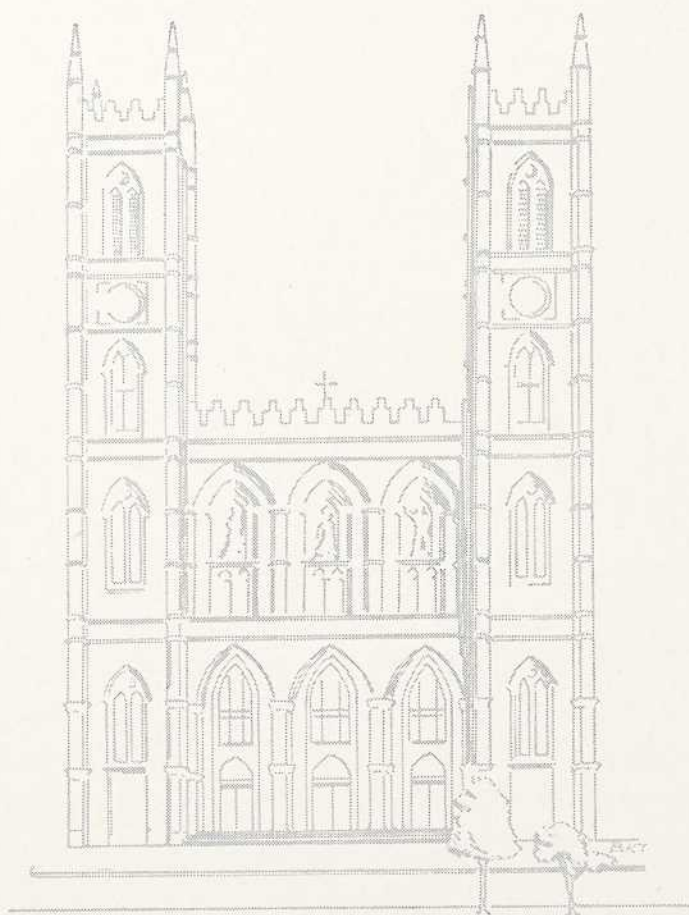
- (12) The existing 3-foot 6-inch trunk sewer on Henri-Julien Street would be relocated along the side of the subway structure to the portal, thence to a junction with the existing sewer. The new portion to be 2 by 3-foot and 4 by 2-foot concrete box sections.

In addition to these major relocations there would be numerous minor changes along the entire length of the initial subway line.

Since we were advised that all trunk sewers are handling their full capacity at this time, we have not proposed to divert the flow of any system into other trunk sewers. In all cases we have endeavored to conform to the regulations of the Public Works Department of the City of Montreal, and estimates of cost for this work have been prepared.

Other Utilities

Other utilities such as water and gas services, underground electrical systems, and traffic signal cables would also be affected by subway construction. A thorough study of the necessary relocations of these utilities has been made and preliminary plans and estimates of cost for this work have been prepared.



CHAPTER VI

DESCRIPTION OF INITIAL SUBWAY

LINE AND GRADE

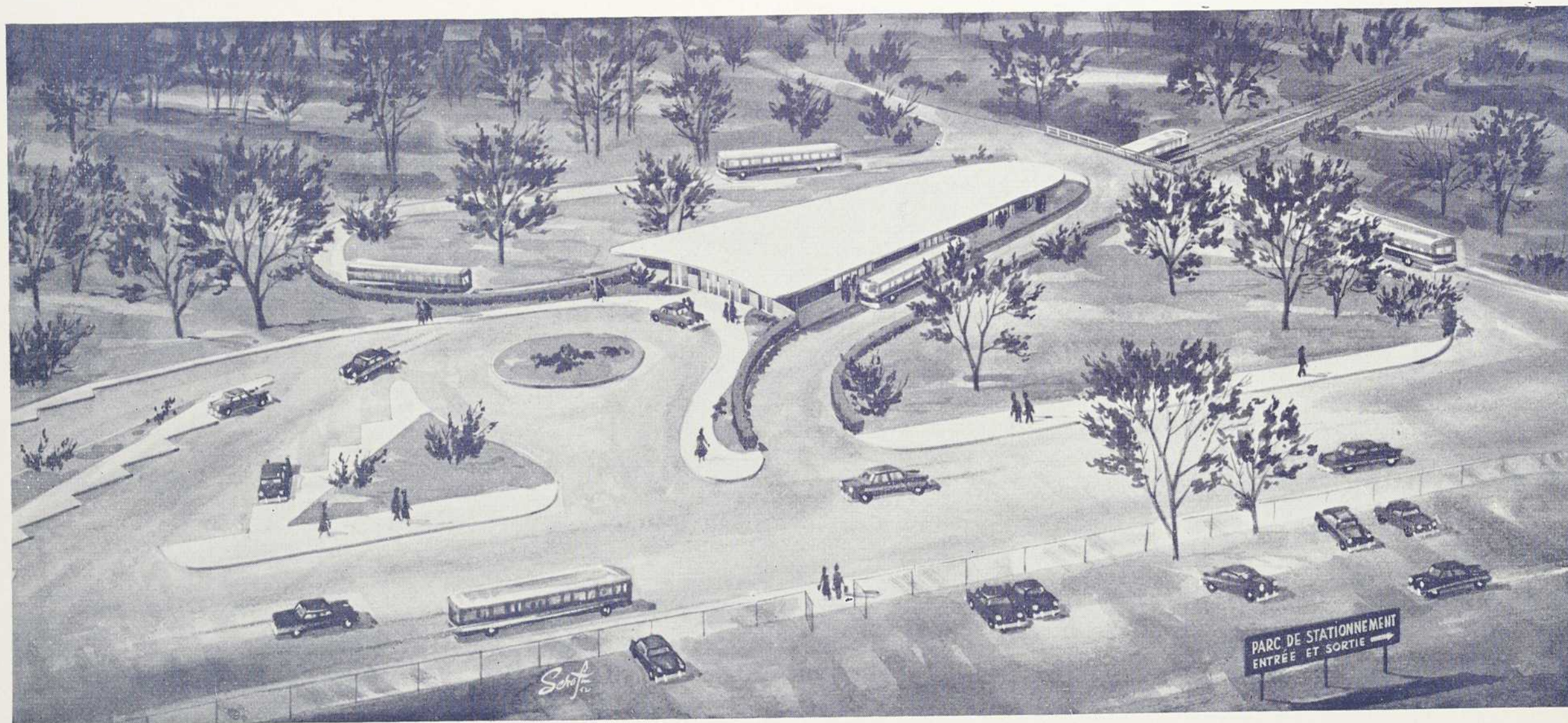
The initial subway, as recommended herein, will start at an underground terminal in the Commission's Youville Yard, north of Crémazie Boulevard. The alignment is such that the subway will reach the centre of St. Denis Street at a point just north of Crémazie Boulevard. From this point, the subway will extend southerly along the centre line of St. Denis Street. See Exhibit 5. The grade line from the Youville Terminal will descend in order that the subway will be located below future Metropolitan Boulevard, which, in this vicinity, will lie one level below the grade of existing streets.

This portion of the route, including the Crémazie station, will be constructed by cut-and-cover methods. At the south end of the Crémazie station, the subway will enter a twin-tube tunnel in rock and will rise on a 1.7 percent grade with from 18 to 30 feet of earth and rock cover over the structure. This will be adequate to permit the construction of mezzanine stations where required from Crémazie Boulevard to Mt. Royal Avenue.

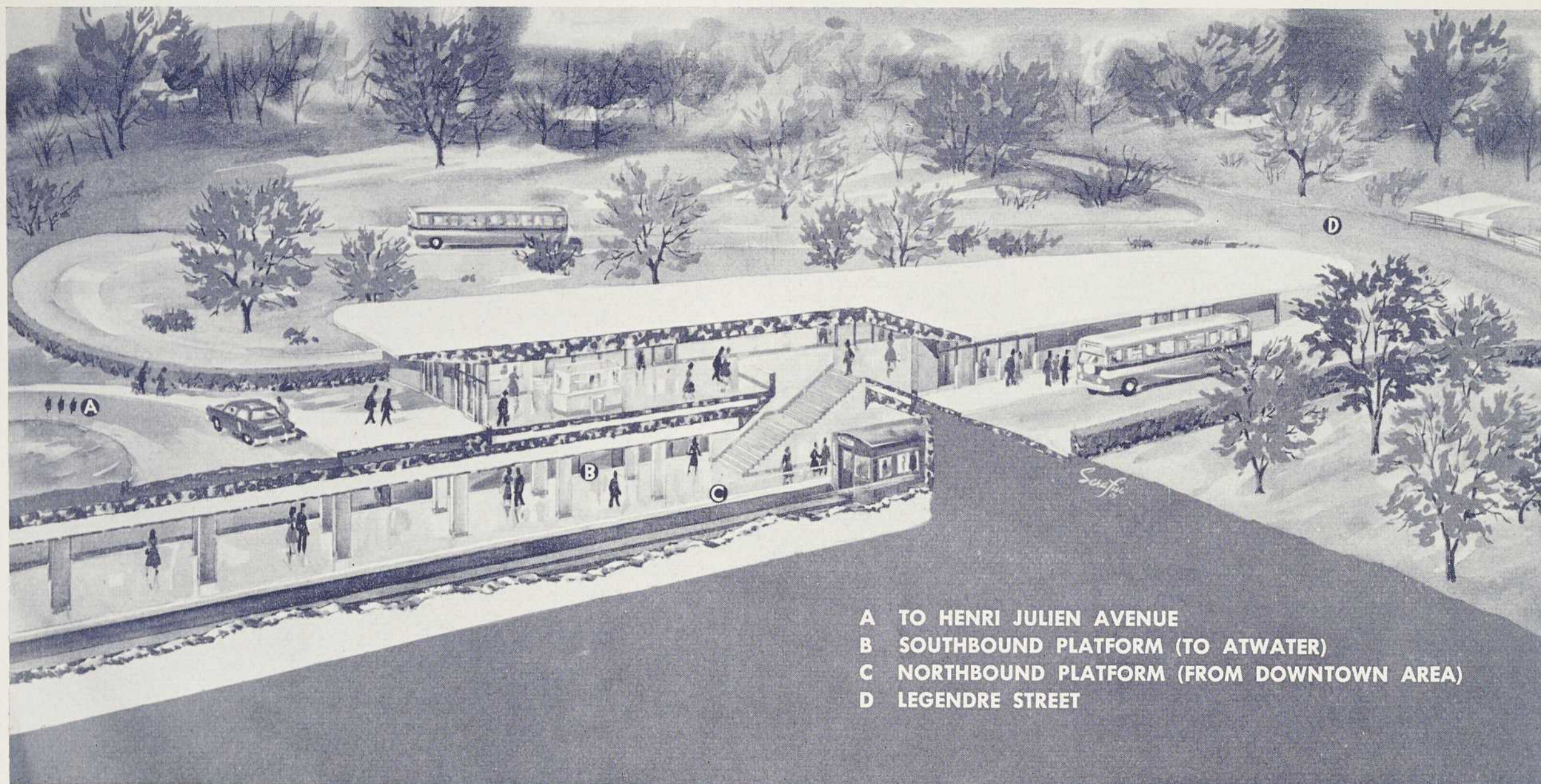
In the vicinity of Villeray Street, the grade will change to conform with the surface topography and will follow an ascending grade to the vicinity of de Fleurimont Street. From this point the grade will descend southward, with from 20 to 35 feet of rock and soil above the roof. At a point north of Marie-Anne Street the type of construction will change from rock tunnel to cut-and-cover as far as Cherrier Street. This portion will be held relatively close to the surface of the street. The roof of the structure will be from 8 to 10 feet below the surface of the street except at the Cherrier station where it will descend to a greater depth in order to allow the construction of the mezzanine station.

The subway will descend on a 3.4 percent grade from Cherrier Street to Ontario Street. Since there will be from 18 to 32 feet of cover over the top of the structure between these limits, the subway will be built in earth tunnel. Open cut construction would require much steeper grades or excessively deep cuts. At a point slightly north of Ontario Street, the cut-and-cover method of construction will be resumed and this method will be used for the remaining portion as described. Throughout this section, the top of the structure will be located as close to the surface of the ground as possible, and still provide adequate space for necessary utilities. This will reduce the length of stairways for passengers between station platforms and the surface of the ground.

At a point approximately 300 feet north of Craig Street, the subway will turn westerly on a curve of 574-foot radius passing under private property and Champ-de-Mars to a point under the centre of St. James Street, just west of St. Gabriel Street. See Exhibit 4. The subway will then follow St. James Street to the west side of the Canadian National Railways viaduct near Inspector Street. There will be from 4.5 to 10 feet of cover over the subway structure within these limits. From the Canadian National Railways viaduct the alignment will turn north-westerly on a curve of 410-foot radius, the subway will pass under private property and Dominion Square, and the grade will ascend at a rate of 3.6 percent to Dorchester Street. Between these points, the earth cover



VIEW OF YUVILLE BUS TERMINAL
Looking Northwest



CUT-AWAY VIEW OF YOVILLE TERMINAL STATION

over the subway will vary from 4.5 to 30 feet. From Dorchester Street the subway will continue in the same direction, it will pass under Dominion Square and intersect Peel Street approximately 400 feet south of St. Catherine Street.

From the point where the subway crosses Peel Street, it will turn westerly on a curve of 478 foot radius passing under private property and meeting the centre line of St. Catherine Street at a point near Drummond Street. Following the centre line of St. Catherine Street, the subway will terminate at Atwater Avenue, in the vicinity of the Forum.

The subway along St. Catherine Street will be of the high-level type, with approximately 8 feet of cover above the roof of the subway, to a point near du Fort Street. From this point to Atwater Avenue, it will descend on a 2.1 percent grade to allow for a mezzanine station.

To permit emergency train movements from one track to the other, cross-overs will be installed at five different locations.

The total length of the subway as described will be 7.78 miles, of which 4.39 miles will be built by cut-and-cover methods, 0.24 mile in earth tunnel, and 3.15 miles in rock tunnel.

STATIONS

Sixteen stations will be provided at an average spacing of one-half mile.

Stations having a mezzanine will be provided at:

Crémazie Boulevard
Villeray Street
Jean Talon Street
Beaubien Street
De Fleurimont Street
St. Joseph Boulevard
Mt. Royal Avenue
Cherrier Street
Dominion Square
Atwater Terminal

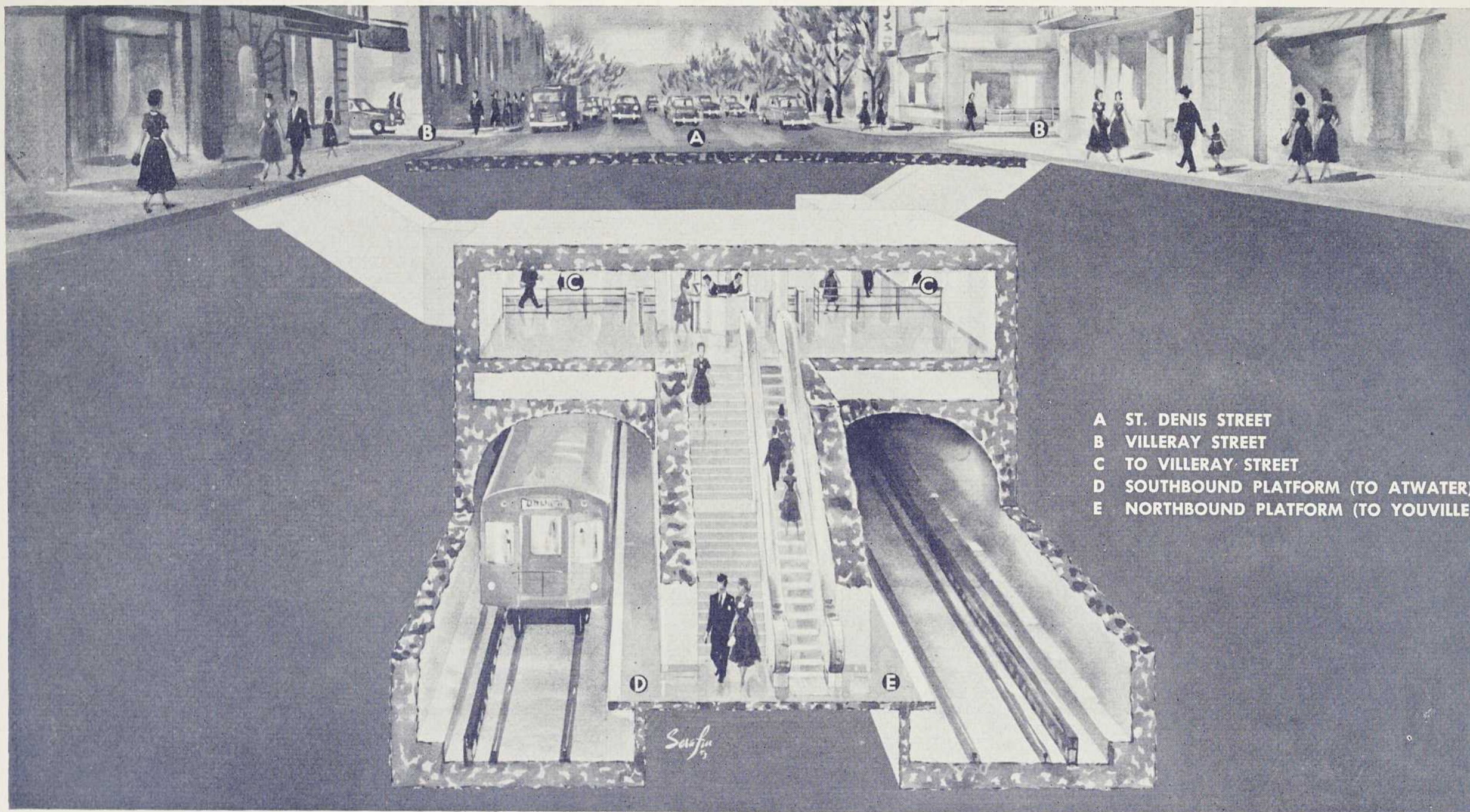
One of the advantages of a mezzanine station is the direct connection from all entrances to trains bound in either direction. A typical station of this type is shown on Exhibit 6.

Escalators as well as stairways will be provided between the train platform level and the mezzanine, with stairways connecting to the street level.

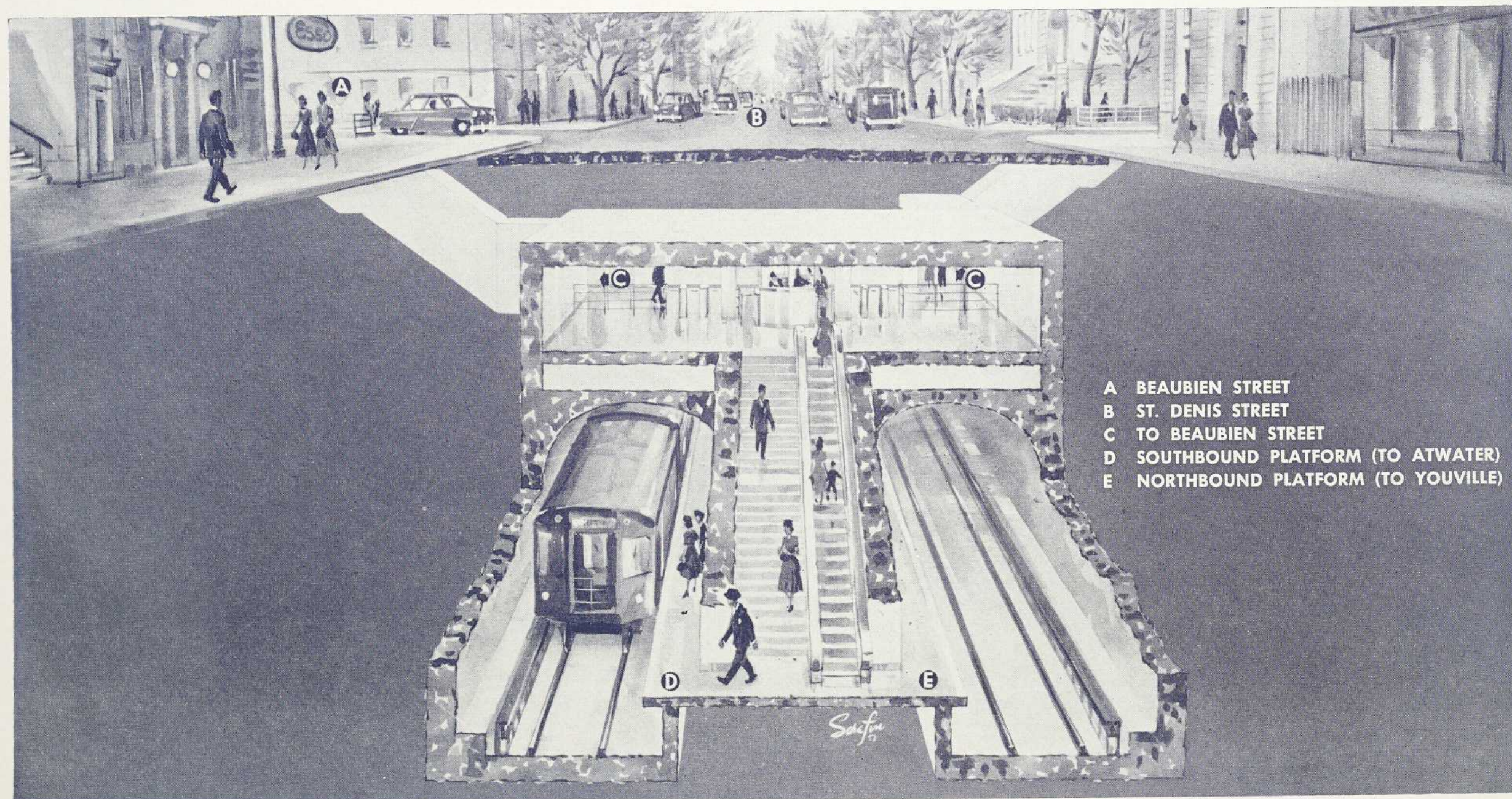
Side platform stations will be used at locations where the subway will be too close to the surface of the ground to permit the construction of a mezzanine.

Stations of this type will be required at:

Youville Terminal
Champ-de-Mars
Place d'Armes
Victoria Square
Guy Street



CUT-AWAY VIEW OF VILLERAY STATION
Looking North



- A BEAUBIEN STREET
- B ST. DENIS STREET
- C TO BEAUBIEN STREET
- D SOUTHBOUND PLATFORM (TO ATWATER)
- E NORTHBOUND PLATFORM (TO YOUVILLE)

CUT-AWAY VIEW OF BEAUBIEN STATION

Looking North

The station on St. Denis Street extending from St. Catherine Street to de Montigny Street will be of the side platform type. However, this station will have a mezzanine payment area at de Montigny Street, and side platform payment areas at St. Catherine Street.

In some instances direct entrances will be provided from the payment areas of the stations to the basement level of adjoining stores and office buildings.

Sidewalks at a few of the proposed station locations are too narrow to permit the construction of stairways between the curb and building lines. At these locations it will be necessary to obtain easements through private property for construction of entrances back of the existing property lines.

Youville Terminal

The Youville Terminal will be located on the Commission's property and will include a bus transfer station at ground level, erected directly above the subway. See Exhibits 7 and 8. This terminal will be flanked by loading platforms under canopy for buses radiating to the Bordeaux, Ahuntsic, and Sault-aux-Récollets districts and to the Town of Montreal North as well as east and west on the future Metropolitan Boulevard.

Passengers arriving on the various buses will transfer to the subway, or between buses, without the use of transfer slips. However, fare booths and turnstiles will be provided for passengers originating their trip at this location.

Capacity for 1,000 automobiles can be provided in parking lots adjacent to the terminal.

Underground facilities will consist of a two-track stub-end terminal with two 500-foot storage tracks beyond the station. These tracks lead directly to the subway car storage yard and repair building and to the existing Youville Shops. See Exhibit 9. A new repair building with car washing and servicing facilities will be provided. Covered storage facilities will be provided at the terminal for all rapid transit cars.

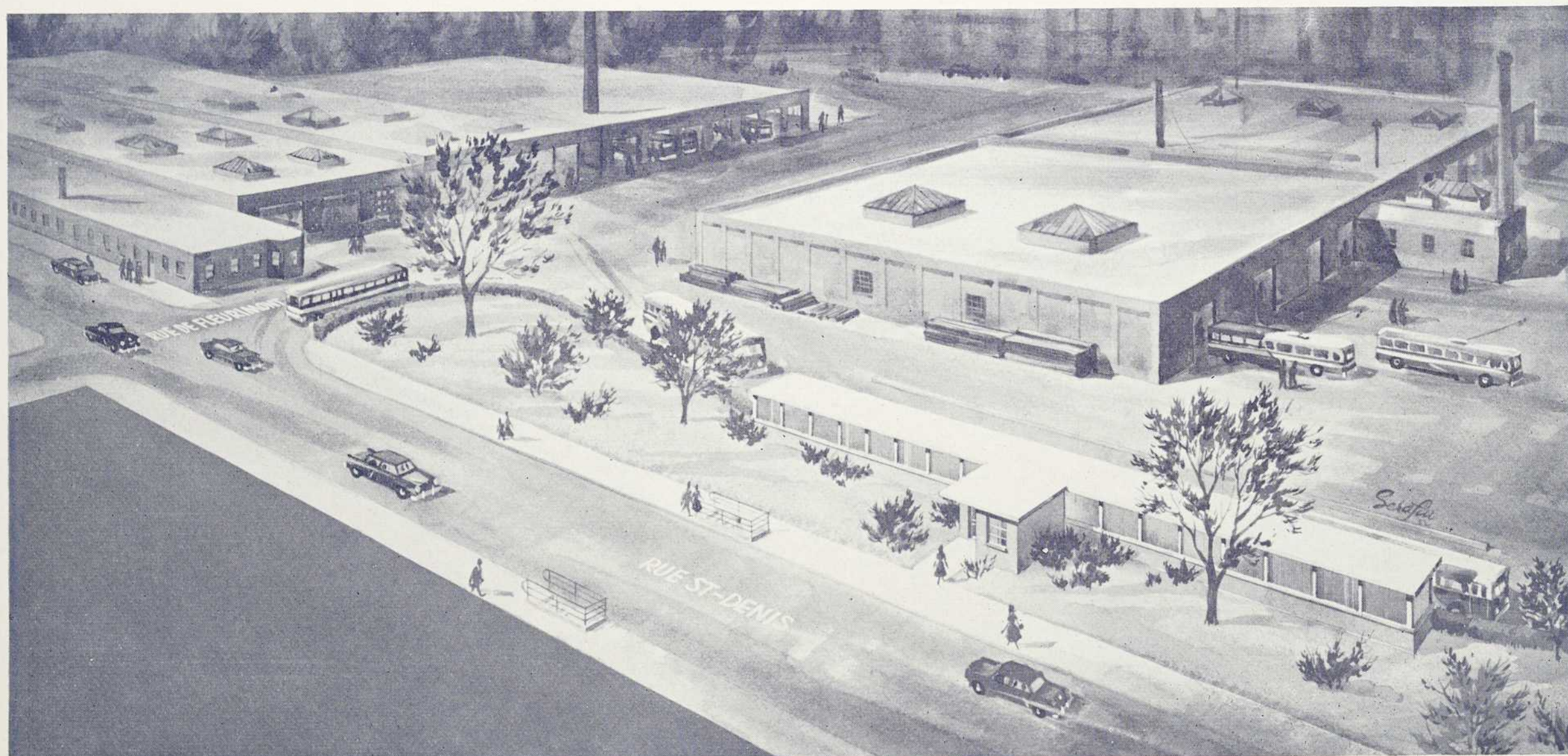
Stations on St. Denis Street Crémazie Boulevard to Cherrier Street

This group of eight stations are placed at the intersections of main east-west arteries to afford the most direct connections with surface transit routes. These surface routes will be altered to function with the subway in order that large numbers of persons living in other parts of the city east or west of St. Denis Street may benefit by using the subway for part of their journey.

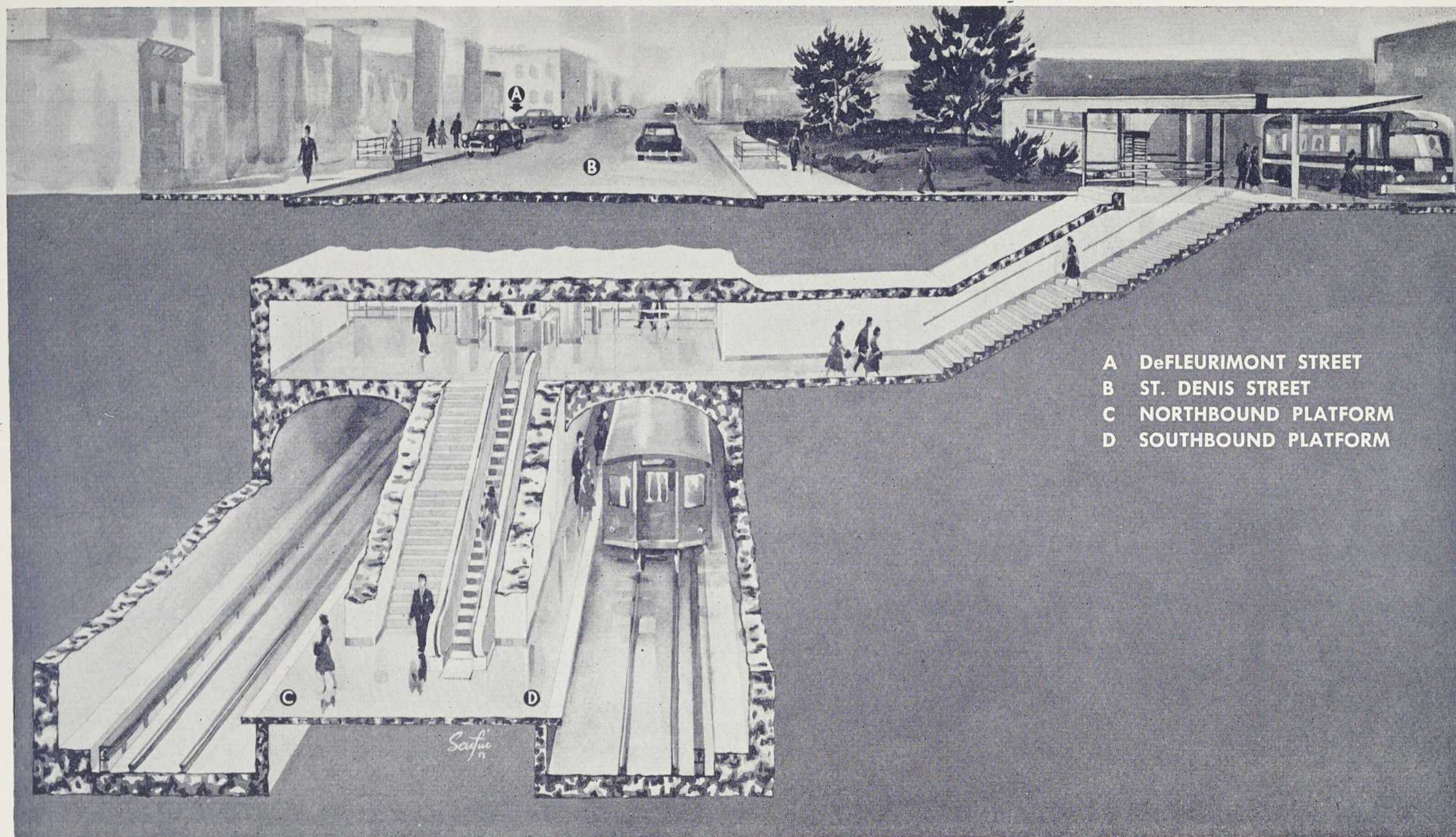
The station at Crémazie Boulevard will have mezzanines located on each side of the future Metropolitan Boulevard in order that passengers will not be required to cross this wide thoroughfare to reach the subway station.

Plates 9 and 10 show the stations at Villeray Street and Beaubien Street and are typical of those located between Villeray station and Mt. Royal station, all of which are in rock tunnel construction.

The station at de Fleurimont Street will have the added feature of an off-street bus transfer station located at ground level, on a portion of the Commission's existing car storage yards. See Exhibit 10.



VUE OF DE FLEURIMONT BUS STATION
Looking Southwest



CUT-AWAY VIEW OF DE FLEURIMONT STATION
Looking South

St. Catherine-DeMontigny Station

A transfer station extending from St. Catherine Street to de Montigny Street, as shown on Exhibit 11, will be provided at the intersection of the initial subway on St. Denis Street with the future east-west subway on St. Catherine Street. The St. Denis subway will be built as the higher of the two and will be the first to be constructed under the recommended program. The structure as built in the initial stage will include a portion of the St. Catherine Street subway immediately below the St. Denis Street subway, and will, therefore, permit future construction of the east-west subway and expansion of the station into a complete and efficient transfer station without disturbance to the previously constructed subway on St. Denis Street.

Entrances and exits to payment areas at platform level will be provided at St. Catherine Street. See Exhibit 12.

A mezzanine with complete facilities for passenger entrance, exit, and fare collection will be provided at de Montigny Street. See Exhibit 13. This station arrangement will conveniently serve the Show Mart and other commercial establishments.

Champ-de-Mars Station

This station will be built under Champ-de-Mars with the surface being put back in the same condition as before. See Exhibit 14. The subway profile will be such that the platforms will be at approximately the same level as the sidewalk of Craig Street. A pedestrian passageway under the track will connect the two side platforms, while a separate passageway will give access to the south sidewalk of Craig Street. Stairways and escalators will be provided to the surface of Place Vauquelin. See Exhibit 15. Direct entry to the basement levels of the City Hall and Court House can be provided if desired.

Place d'Armes Station

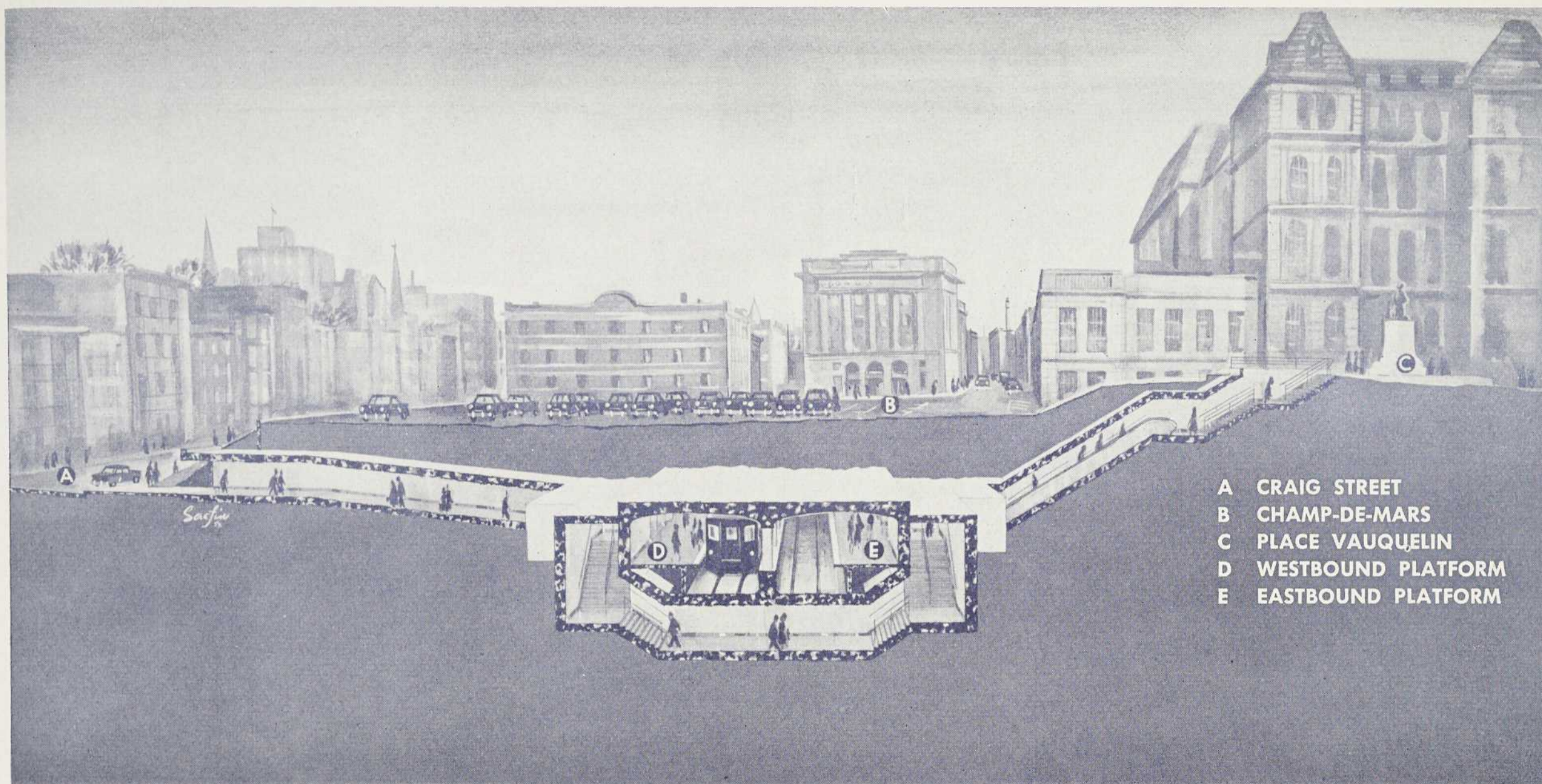
This station will be in the heart of the financial district and, therefore, will serve thousands of people working or conducting business in the immediate vicinity. See Exhibit 16. This station will also serve the wholesale district and the dock and port areas between St. James Street and the St. Lawrence River.

Place d'Armes station will also function as a transfer point between the subway and Craig Street Terminal. While there will be a major rearrangement of surface routes in connection with the construction of the first subway, it is planned that a number of routes will continue to terminate at the existing Craig Street Terminal.

A passageway under the tracks will connect the two side platforms and continue approximately level to Craig Street where stairways will lead to the sidewalks and to the concourse of Craig Street Terminal. Entrances and exits will be provided on Place d'Armes and on Place d'Armes Hill. See Exhibit 17. Arrangements are such that pedestrians may freely use the passageway between Place d'Armes and Craig Street.

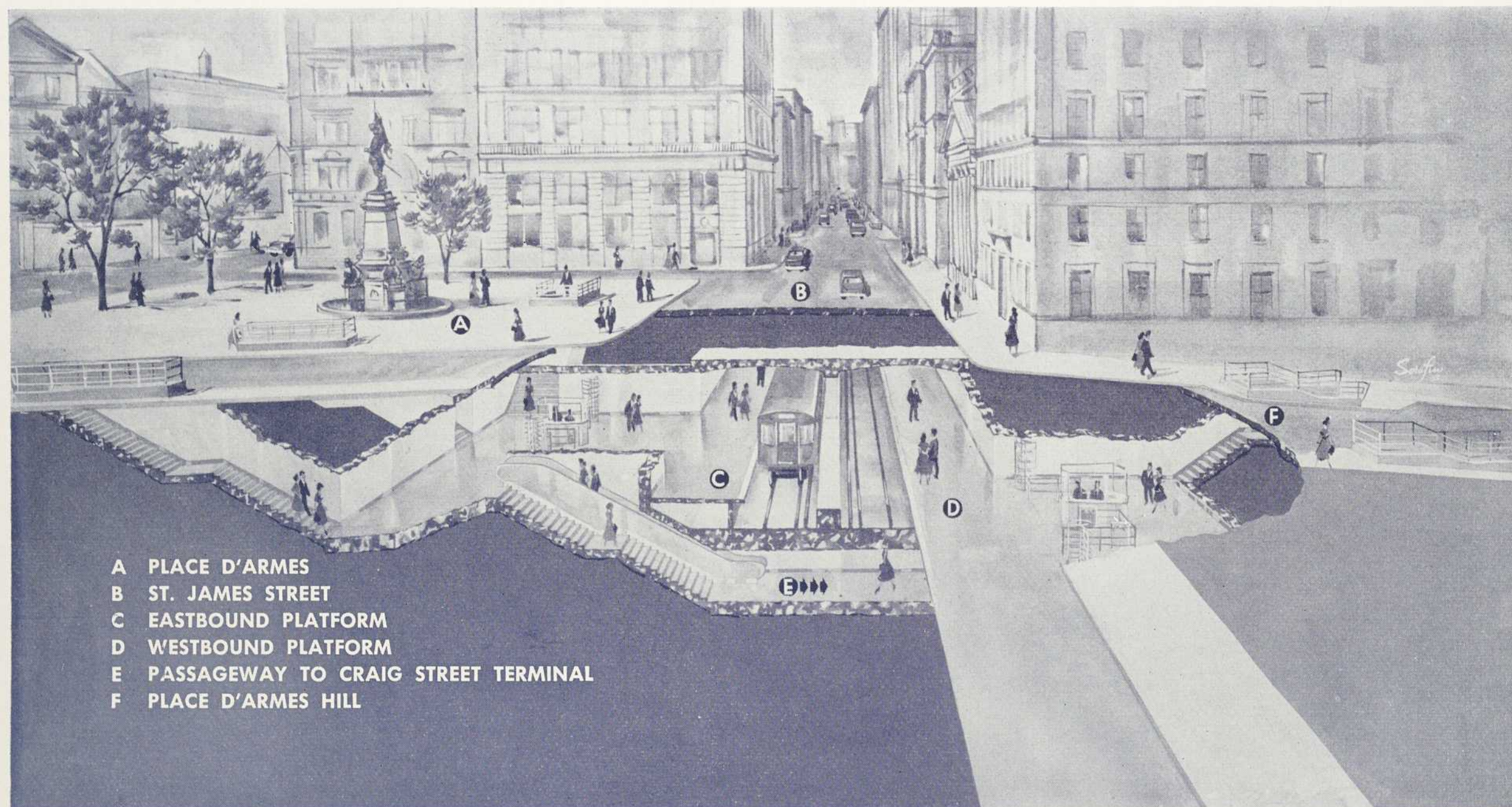
Victoria Square Station

This station will be located on St. James Street at McGill Street. See Exhibit 18. The latter is the only street in the vicinity providing access by public transportation to the important dock area and wholesale district lying immediately to the south. In addition there are a number of office



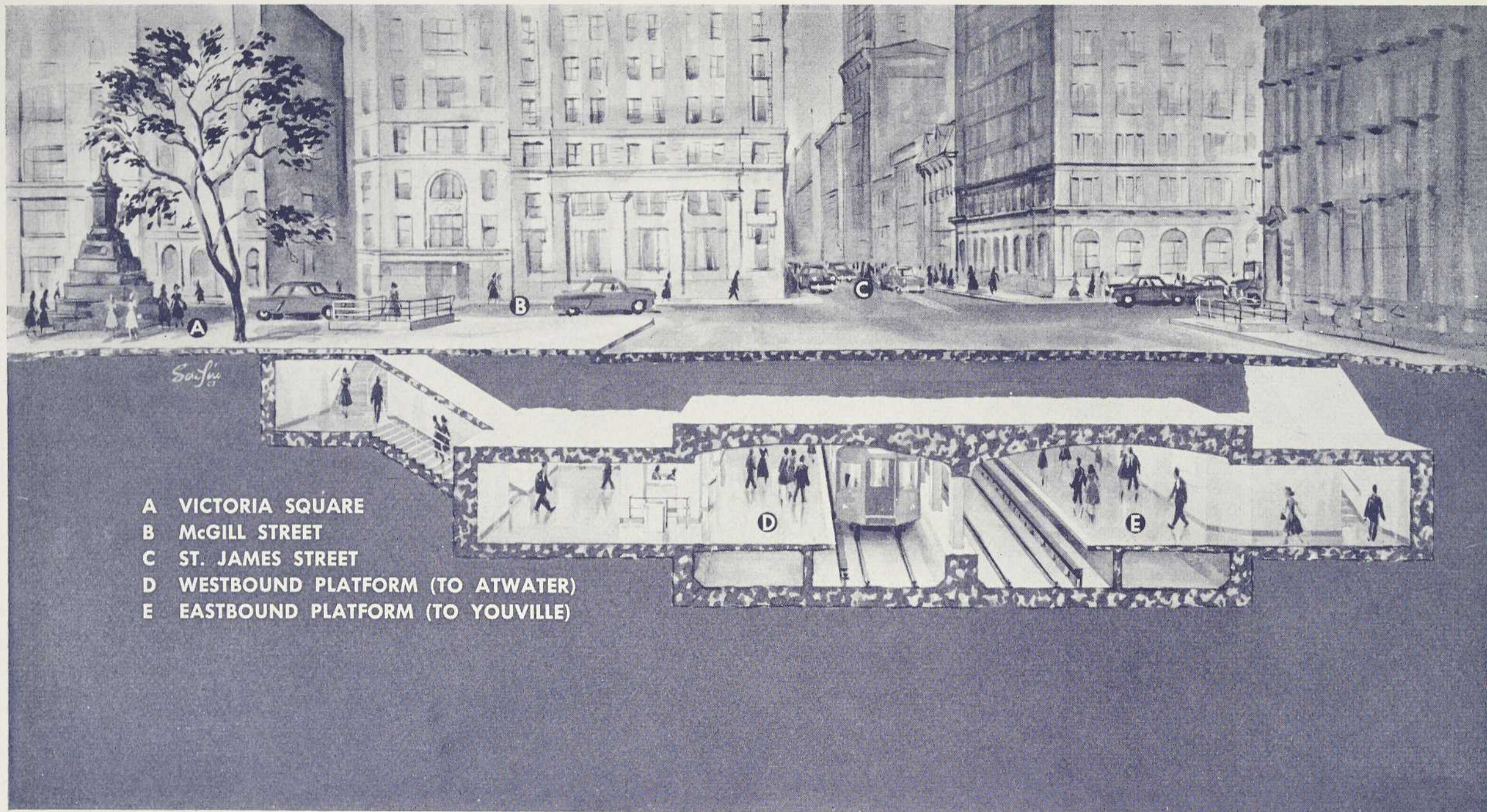
- A CRAIG STREET
- B CHAMP-DE-MARS
- C PLACE VAUQUELIN
- D WESTBOUND PLATFORM
- E EASTBOUND PLATFORM

CUT-AWAY VIEW OF CHAMP-DE-MARS STATION
Looking East



CUT-AWAY VIEW OF PLACE D'ARMES STATION

Looking West on St. James Street



CUT-AWAY VIEW OF VICTORIA SQUARE STATION

Looking East on St. James Street

buildings and commercial establishments in this immediate area. For these reasons, and the fact that several important surface routes from the southwest part of the city will intersect the subway at Victoria Square, this station will be a heavy transfer point.

Dominion Square Station

The Dominion Square station will be strategically located between the Windsor Station of the Canadian Pacific Railway, and the Central Station of the Canadian National Railways. See Exhibit 19. Pedestrian passageways will extend from the south mezzanine, located in Dominion Square south of Dorchester Street, to the vicinity of each of these railway stations. See Exhibit 20. A north mezzanine is planned for the Dominion Square station which will be within a few hundred feet of several of the City's largest hotels, office buildings, department stores, and theatres. See Exhibit 21. Complete facilities for passenger entrance, exit, and fare collection will be provided at both ends of this station.

Guy Street Station

The Guy Street station will be located in St. Catherine Street at Guy Street. See Exhibit 22. It will serve a rapidly growing retail and office building district. This station will serve as a transfer point to and from surface lines operating on Guy Street and Côte des Neiges Road.

Atwater Terminal

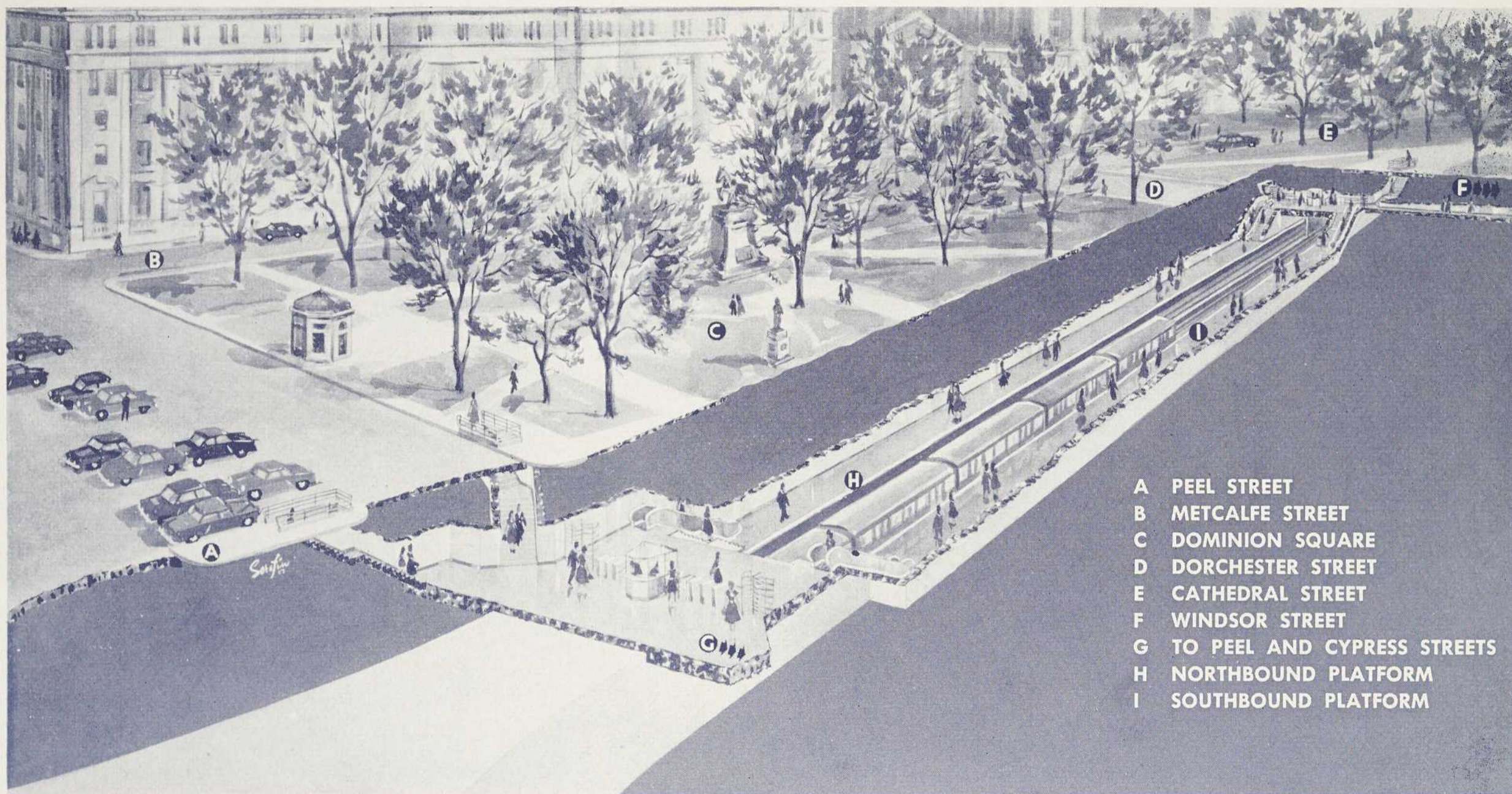
The initial subway will end in a four-track stub-end terminal near the intersection of Atwater Avenue and St. Catherine Street. See Exhibit 23. There will be a mezzanine station on St. Catherine Street directly in front of the Forum. Two tracks serving an island platform will be required for normal operation, while storage facilities for 32 cars will be provided on the additional tracks. Passengers will be provided with adequate connections with the Forum, as well as with the surface of the ground, by means of passageways and stairways. See Exhibit 24.

Surface facilities will consist of two bus terminals, as shown on Exhibit 23. First an off-street bus transfer station along the north side of Western Square where bus routes from the City of Verdun, Town of La Salle and southwest sections of Montreal will terminate. Stairways will connect this bus terminal directly with the subway mezzanine.

The second bus terminal will consist of a station located on property west and north of the intersection of St. Catherine Street and Atwater Avenue. See Exhibit 25. Here bus routes from the City of Westmount, Town of Montreal West and the northwest section of Montreal will terminate, as will local bus services on St. Catherine and Dorchester Streets. Direct connection between this bus station and the subway will permit passengers to transfer without the use of transfers. Provision is also made for passengers to pass underground between the two bus terminals when transferring between the various bus routes.

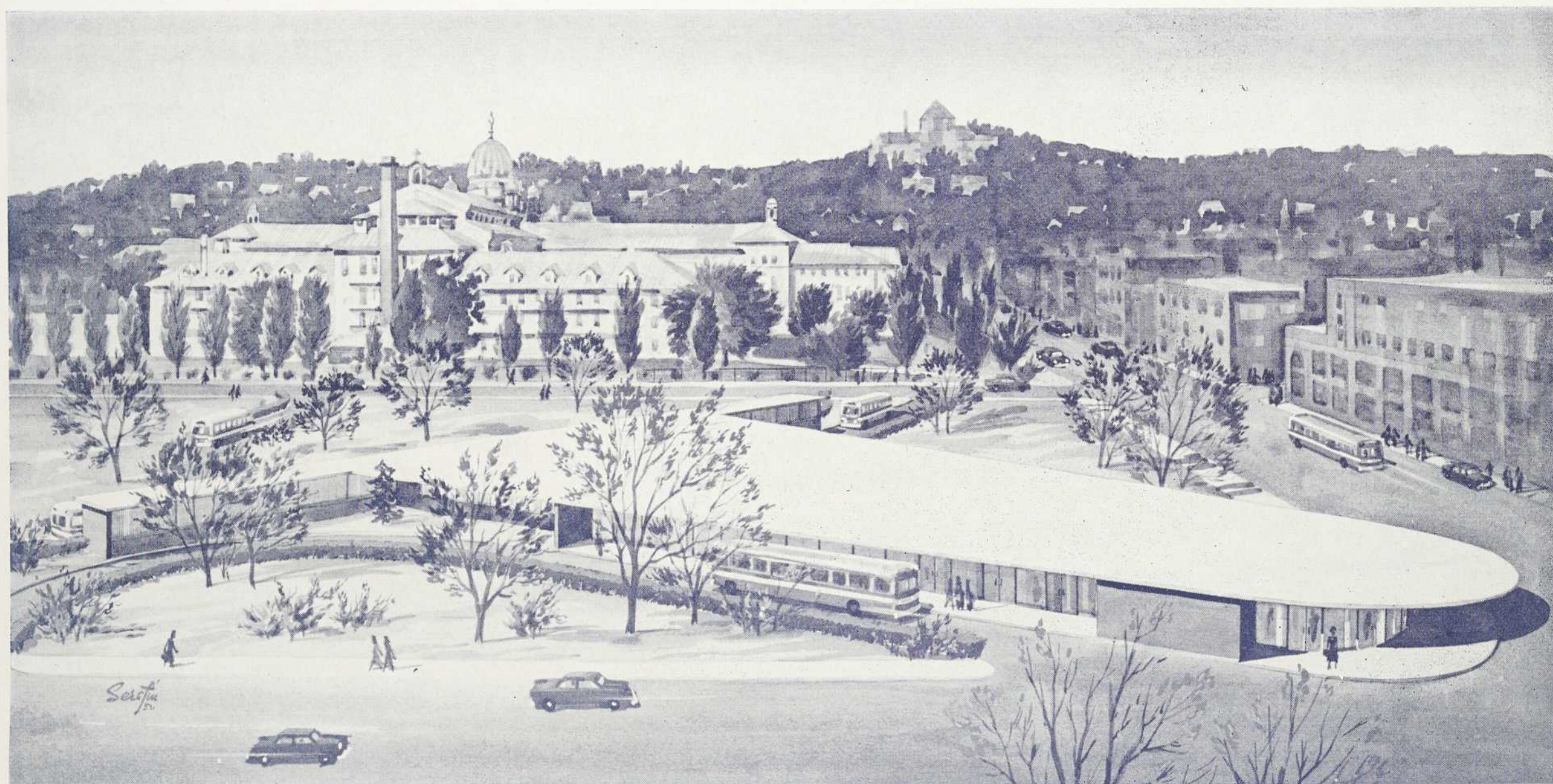
Passengers originating in this area will gain access to the subway or either bus terminal by way of entrance and payment areas located in the subway mezzanine and in the bus terminal on the northwest corner of the intersection.

A parking garage or other commercial buildings could be built on this northwest property.

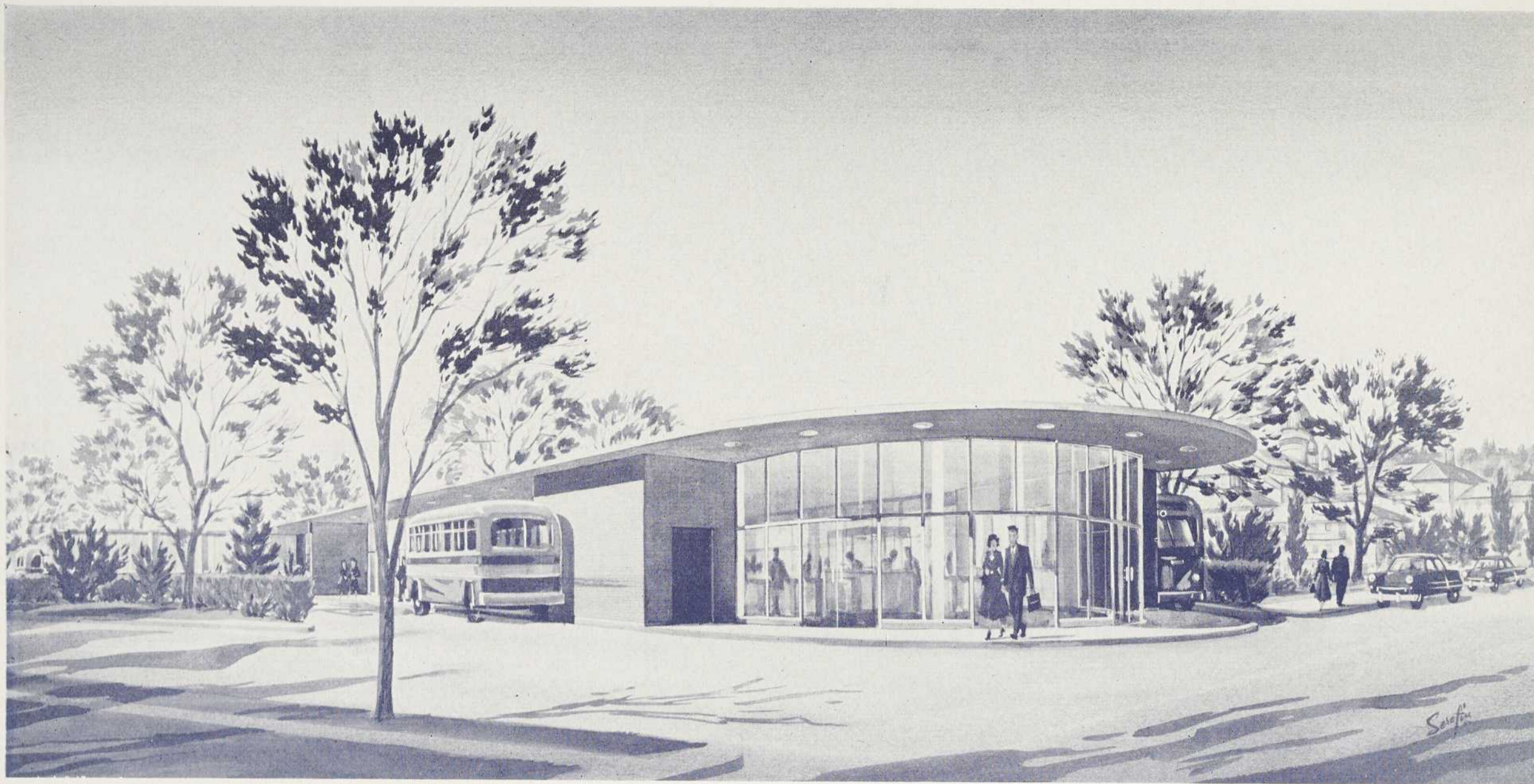


- A PEEL STREET
- B METCALFE STREET
- C DOMINION SQUARE
- D DORCHESTER STREET
- E CATHEDRAL STREET
- F WINDSOR STREET
- G TO PEEL AND CYPRESS STREETS
- H NORTHBOUND PLATFORM
- I SOUTHBOUND PLATFORM

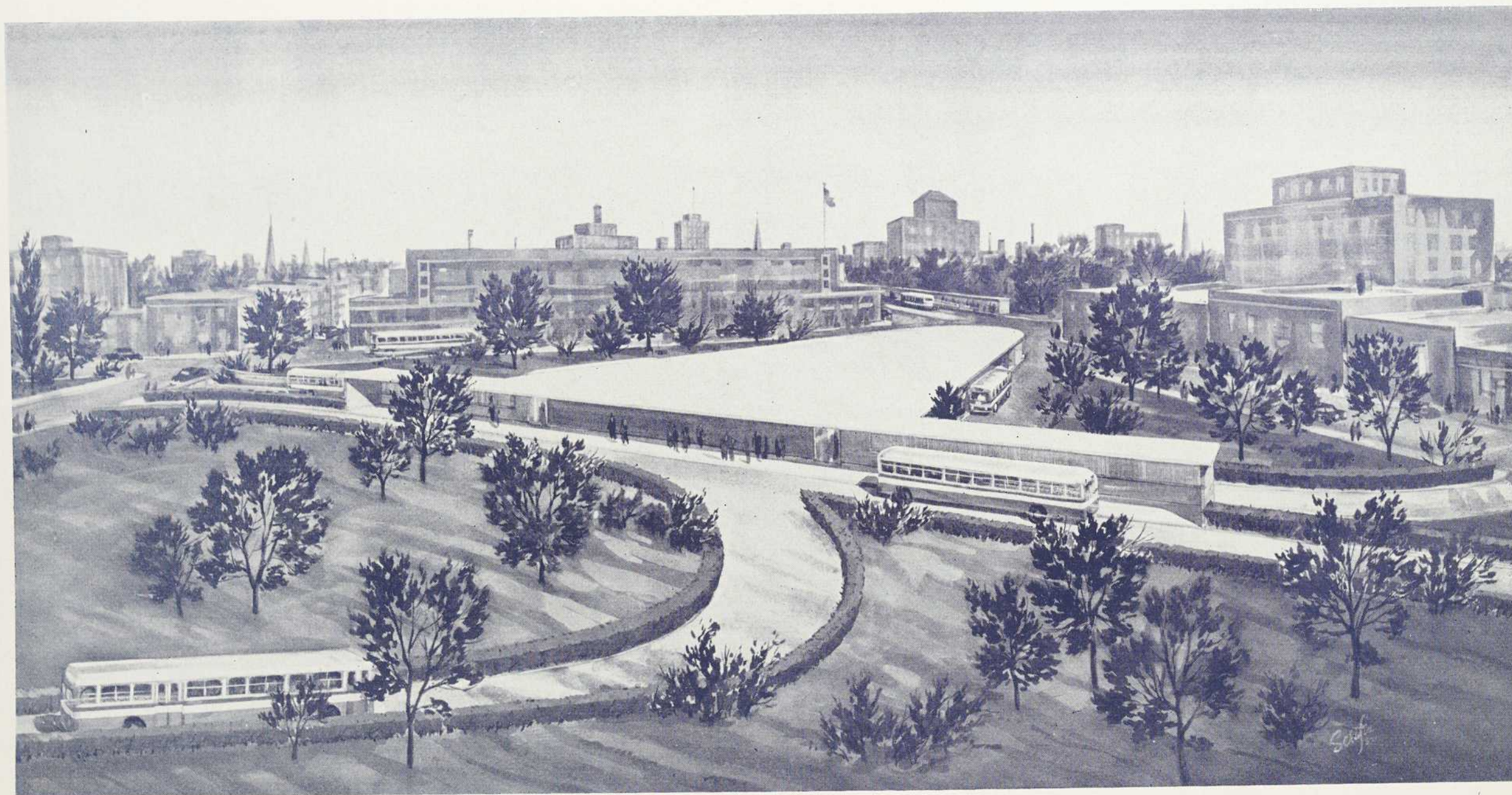
CUT-AWAY VIEW OF DOMINION SQUARE STATION
Looking Southeast



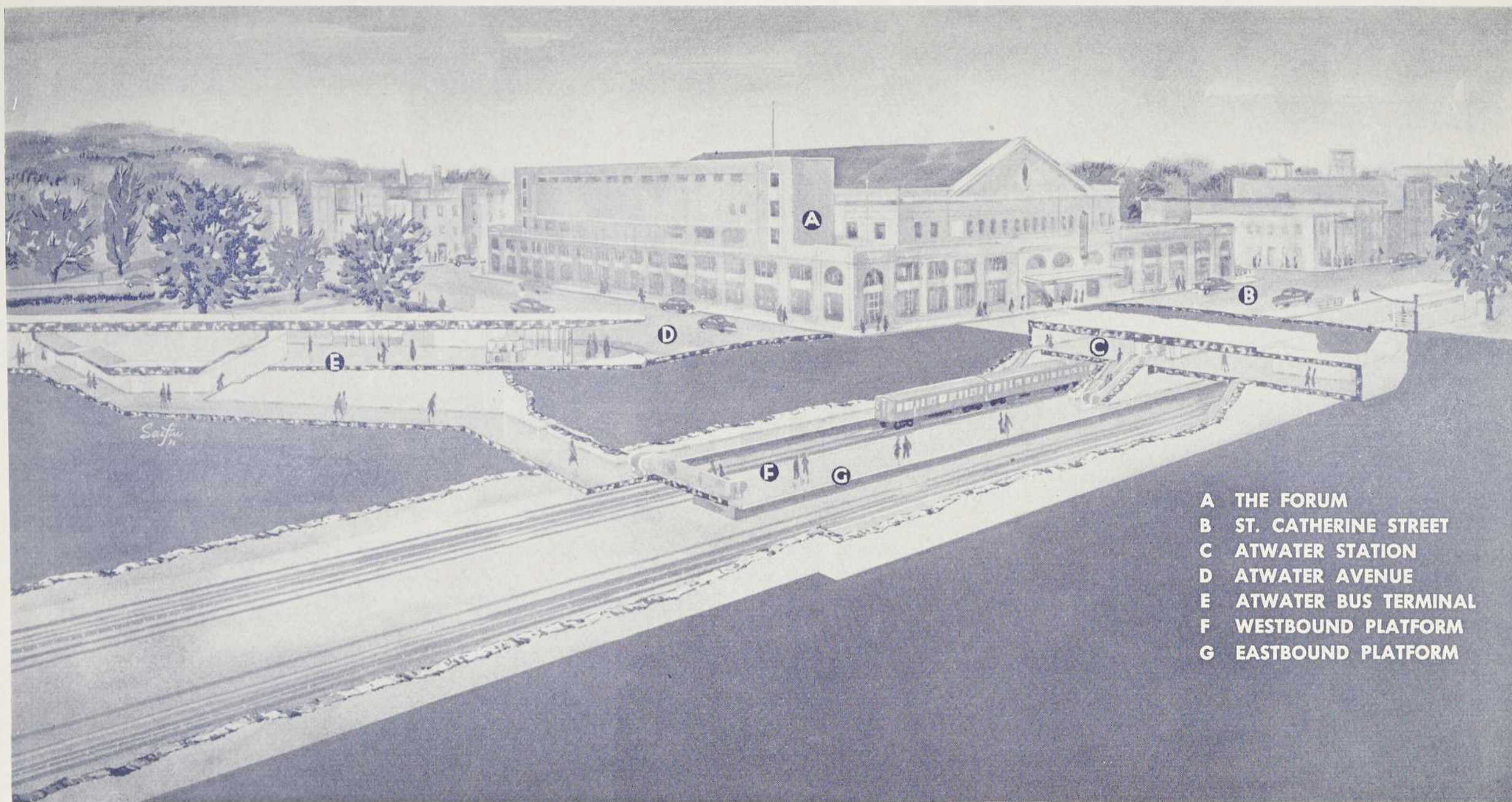
ATWATER BUS TERMINAL
Looking North



ATWATER BUS TERMINAL
Entrance at St. Catherine Street and Atwater Avenue



ATWATER BUS TERMINAL
Looking East



- A THE FORUM
- B ST. CATHERINE STREET
- C ATWATER STATION
- D ATWATER AVENUE
- E ATWATER BUS TERMINAL
- F WESTBOUND PLATFORM
- G EASTBOUND PLATFORM

CUT-AWAY VIEW OF ATWATER TERMINAL
Looking Northeast

GENERAL FEATURES

To speed fare collection and also to keep operating costs at a minimum, there will be coin and token operated turnstiles in addition to the cashiers to make change at all stations. Machines will also be installed which will issue transfers.

Escalators will be reversible to facilitate movement of peak hour traffic.

The side platforms at the high-level stations will vary in width from 12 to 16 feet. The centre, or island platforms, at mezzanine stations will vary in width from 22 to 24 feet. Station platforms will be 500 feet in length to permit simultaneous entry to and exit from all cars in a train of maximum length.

Floors in all stations will be of terrazo, while walls will be of tile, terra cotta, or structural glass, or other mar-proof and easily cleaned materials with trim of stainless steel, aluminum, or copper. If desired the color scheme at each station could vary to assist in quick identification. News-stands, parcel lockers, telephones, and other conveniences will be furnished for patrons.

A band of sound dampening material will be installed throughout the subway to decrease the noise created by moving trains.

Walkways will be provided on one side of each tube between stations.

Elaborate precautions have been taken to assure adequate ventilation. Movement of air in and out of a subway serves three purposes, namely; to dispose of heat, to eliminate condensation, and to supply fresh air for passengers. The heat is generated by traction motors, electrical resistors, and braking.

The volumes of air required to eliminate the heat and condensation will be so planned and controlled that there will be no unpleasant drafts created for passengers standing at stations.

Adequate ventilation will be secured by placing ventilating shafts to the surface of the ground at 400 to 500-foot intervals between stations, as well as at each end of the respective stations. Through these shafts, air will normally be drawn up or down by the piston action of the moving trains. By locating shafts at this spacing, the amount of heat generated by the subway trains will be dissipated effectively.

An outstanding feature designed for the future comfort of the patrons of the proposed subways is the station lighting. The Chicago subway, completed in 1943, provided lighting intensities on platforms and mezzanines of 5 to 6 foot-candles. This was a spectacular advance over the best lighting in subways built prior to that time. However, in the Toronto subway now under construction, intensities of 10 foot-candles in stations will be commonplace and 15 foot-candles of lighting will be used in stairways and other critical areas.

The lighting proposed for the Montreal subways will equal that being installed in Toronto. This will be accomplished by panels of fluorescent lights on the mezzanine levels providing a soft, uniform distribution of illumination. On the passenger platforms at train level, there will be a continuous line of fluorescent fixtures suitably located above the platform edges to afford the best results. Fluorescent lighting will also be used to illuminate passageways and stairways.

In addition, suitable provision will be made for an emergency lighting system which will provide sufficient illumination to permit operations to continue in case of failure of the normal lighting circuits.

CHAPTER VII

EQUIPMENT FOR THE INITIAL SUBWAY

VENTILATION

The need to circulate large quantities of fresh air through a subway to prevent vapor condensation and to dissipate heat, thus ensuring health and comfort of passengers, has been dealt with in a section of the previous chapter. With proper location and design of vent shafts, the piston action of moving trains will provide adequate ventilation under normal conditions. Large axial flow fans will be installed for emergency use, however, in vent shafts located between stations. These fans will be reversible.

All vent shafts will be provided with louvres for use in conjunction with fan operations. All fans and dampers will be controlled from the central supervisor's control room, with alternative individual control at each ventilation shaft.

ELECTRICAL FACILITIES

The superior station lighting to be installed has been described. Electrical energy for this lighting and also for the auxiliaries such as ventilating fans, pumps, escalators, signals, and similar equipment, will be supplied in the form of alternating current from power and distribution facilities at each station structure. The distribution facilities will include dual supply sources. In case of failure from any cause, automatic transfer switches will immediately change to another source of supply.

In the event of a general power failure, emergency platform lights, tunnel lights, and other essentials will be supplied from a separate direct current source.

TRACTION POWER

Each subway car will be powered by direct current traction motors with their associated controls. This has proven to be the most satisfactory method of obtaining high starting torque, variable speed operation, smooth acceleration and deceleration rates, and other very desirable characteristics.

For economic reasons electric power will be received in the form of alternating current at 12,000 volts and distributed to 7 substations, located about 1 mile apart, along the initial subway. In these substations, the power will be converted into the form of direct current at 600 volts for distribution to the subway cars. The cars will receive positive current, through the medium of a sliding shoe, from a high conductivity third rail made of special steel. Negative current will be returned to the substation through one of the running rails supplemented by a copper feeder cable.

To facilitate maintenance and repairs, the third rail and direct current distribution network will be sectionalized so that power may be interrupted in any one or more sections without affecting the movement of cars in the balance of the subway.

SUPERVISION OF TRACTION POWER AND ELECTRICAL FACILITIES

Because of the extent of the project and of the variety of equipment essential to its operation, a supervisory remote control system of the all-relay type will be installed in the vicinity of the Craig Street Terminal. This system will permit constant supervision of all substation apparatus, traction feeder breakers, lighting and other station facilities, ventilating fans, pumps and similar equipment, by means of signal lights on a control panel. While most of the equipment will function automatically, control keys on the panel will permit the supervisor to control all electrical facilities.

EMERGENCY ALARM AND TELEPHONES

The emergency alarm system will be similar to the usual city fire alarm system. It will provide alarm boxes at numerous locations and each box will relay a code signal to the supervisor's office. Thus, in case of a mechanical equipment failure, a motorman or any other employee will be able to signal quickly for the de-energizing of all power lines in the vicinity of the trouble.

A complete automatic telephone system will be installed in the subway. This system will provide communication not only to all points of the subway but to the outside as well.

SIGNAL AND INTERLOCKING SYSTEM

A signal system of the most modern type will be installed in the subway. The apparatus will be such as to provide the highest degree of safety and reliability in high speed rapid transit train service. The system will be designed, installed, and operated in accordance with standard specifications for this type of equipment.

The signal system will consist of wayside color-light signals located adjacent to the track which they govern. These signals will convey to motormen, by means of colored lights, information as to the proper procedure to be followed for the safe and expeditious operation of their trains. Interlocking home signals will indicate the route to be taken by trains in addition to the normal *Stop*, *Proceed with caution*, and *Proceed* information.

The tracks will be divided into sections or blocks, and the movement of a train into each section or block will be governed by a signal and a train stop. The length of each block is intended to equal the braking distance for the expected maximum speed of a train as it enters that block plus an additional length as a factor of safety.

Associated with each block, approach, and home signal there will be a wayside train stop which will automatically engage trip arms on the train, thereby applying the brakes and enforcing obedience to the *Stop* communication of the signal. Each train will always be protected from the next succeeding train by a signal and a train trip, both in the *Stop* position.

Interlocking facilities between track switches and the signal system as above described will be provided at all terminals, emergency crossovers, and other special trackwork locations. The interlocking plant will be under the control of a dispatcher posted at central office in the vicinity of Craig Street Terminal; the dispatcher will know at all times, through light indications on his central train control board, the position of all trains, of every switch on the system, as well as the indication of every wayside signal and associated train stop.

TRACKWORK

Numerous studies were made to develop a superior type of track. Full consideration was given to initial cost as well as to future maintenance expenses, and to both quiet operation and riding comfort. The subway tracks will be constructed of 100-pound American Railway Association, type A, rail and fastenings. The standard gauge of 4 feet 8½ inches will be used. Throughout the length of curves, 85-pound CPR section restraining rails will be installed on the inside of the inner running rail of each track.

The tracks will be anchored to the concrete invert slab rather than to full or half-ties imbedded in concrete. At special locations where crossovers are installed, standard tie and crushed stone ballast construction is proposed; this crosstie, 8 inches by 6 inches by 8 feet long, will be of treated hardwood. Every fifth tie will be 9 feet in length to provide for the support of the positive contact rail. All rail joints will be thermit welded to reduce noise, improve the riding qualities of the track, and increase the life of the rail.

To provide flexibility to the track and to reduce noise to a minimum, a ¾ inch thick composition rubber pad will be used between the concrete and the tie plate. The tie plates and pads will be anchored to the invert slab by two fully insulated anchor bolts in opposite corners of the tie plates. On tangent track the rails will be anchored on 2-foot 6 inch centres while on curves the anchorage will be on 2-foot centres.

The rail is attached to the tie plates by short bolts and spring rail clips, with the bolt heads countersunk into the bottom of the tie plates.

Standard railroad frogs and switches will be used in the main running tracks of the subway system. Crossovers and turnouts will be in accordance with the American Railway Engineering Association standards for No. 8 turnouts. In the yard layout No. 6 turnouts will be used.

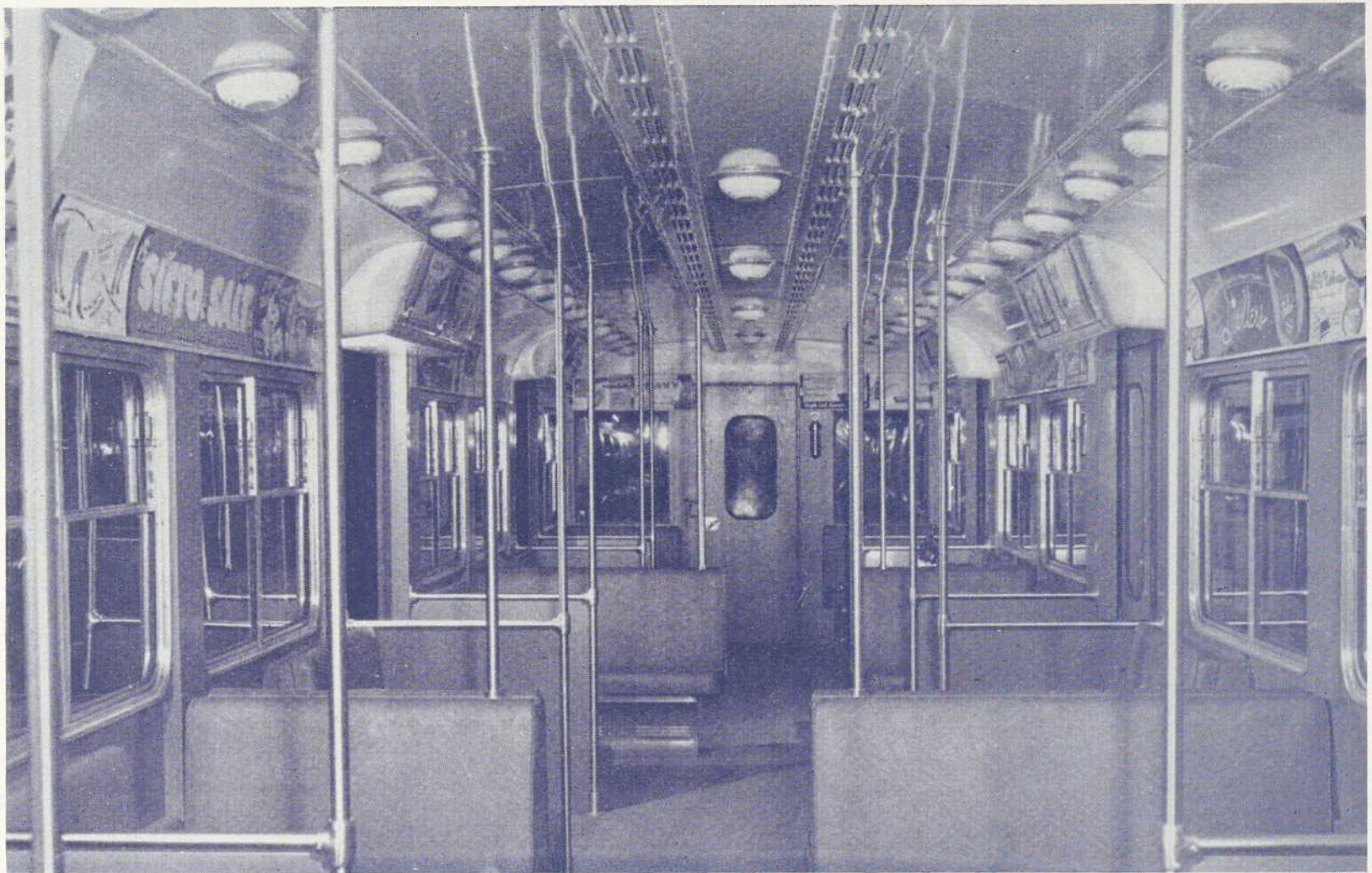
Horizontal curves sharper than 30 minutes (11,459-foot radius) will be spiralled. Parabolic vertical curves will be used to connect grades when the algebraic difference in gradients exceeds 0.3 of a foot per 100 feet.

The special contact rail, mounted on porcelain insulators anchored to the invert slab, will be a special high-conductivity section weighing 150 pounds per yard. As a safety feature, the contact rail will be located outside of the outer running rail through stations. The contact rail will be shielded throughout by a wooden plank assembly.

SUBWAY CARS

Recent developments in rapid transit cars, both in North America and Europe, afford the opportunity to provide a vehicle of outstanding performance and comfort for the Montreal subway.

For some years the Transit Research Corporation and others in the United States have been developing a car of moderate length and weight which embodies many of the features applied successfully to the P.C.C.-type streetcar such as resilient wheels, rubber springing, and smooth but high rates of acceleration and deceleration. These designs feature dynamic braking which eliminates the abrasive dust of brake shoes on wheels — an important consideration in an underground railway. Car body design is simple and pleasing and the interior is arranged to provide easy and rapid entry and exit of passengers. Cars of this type have been put in use lately on some United States rapid transit systems.



Interior View of Proposed Toronto Subway Car



New Subway Car — New York City

The latest subway cars supplied to the London Underground by British manufacturers are equally attractive and have excellent operating characteristics. These cars are semi-light weight and a little longer than some of the United States designs. A slightly modified version of the London car is being supplied for the Toronto subway.

An interesting experiment is presently being conducted in Paris in the field of subway rolling stock. A short section of the Paris subway between Pré St-Gervais and Porte des Lilas has been operated for about eighteen months with cars mounted on pneumatic rubber tires, which reduced noise to a minimum and gave very smooth operation. We are watching this trial with great interest and when the type of subway car is selected, consideration will be given to these vehicles if the results are found to be satisfactory and economical.

While no detailed specifications have been prepared for Montreal subway cars at this stage, full advantage will be taken of the most recent developments here and abroad.

In general, provision has been made for cars up to 60 feet in length and 10 feet in width. Trains will be made up of from two to eight such cars. Rapid, smooth acceleration is an important element in the speed and comfort of subway travel and can be achieved with modern automatic control devices. A maximum speed of 50 miles per hour on level track is contemplated.

Car floors will be level with station platforms and sufficient doors of ample width will be provided for rapid interchange of passengers. Ventilating and heating systems will be installed in each car. A thermostatically controlled air supply to provide a constant comfortable temperature will be delivered through louvres beneath the seats. Lighting will be designed to give an even illumination without glare and an intensity of about 20 foot-candles at the reading level. Power for a few lamps will be supplied from a battery, so that the car will not be in complete darkness in case of power failure or other emergency.

Sound-deadening materials will be incorporated in the body structure. Floors will be of nonslip material and free from sharp angles and nooks which accumulate dirt and litter.

All doors on either side of the train will be controlled simultaneously by the train guard. Automatic reversing devices will be applied to the doors so that there will be no danger of a passenger being caught by the closing doors. End doors will be provided in the cars to allow easy and safe passage between cars.

All proven safety devices will be used including automatic stoppage of the train if the motorman relaxes his hold on the control handle; automatic stoppage if a stop signal is passed; manual operation of any door by passengers in case of emergency; and various other provisions for safety.

Power will be supplied by the third rail system at 600 volts direct current. Operating controls will be installed at each end of each pair of cars, so that reversible trains of various capacities can be operated according to the passenger traffic requirements.

On the basis of 55 to 60-foot cars, the total rolling stock required for the initial subway will be as follows:

Service maximum	144 cars
Spare (11%)	16 cars
	—
Total	160 cars

CHAPTER VIII

ADVANTAGES OF PROPOSED SUBWAYS AND MODERNIZATION OF SURFACE SYSTEM

ADVANTAGES OF SUBWAY

Subways are, in effect, underground streets for the exclusive use of high-speed, high capacity public transportation vehicles. Subways can deliver large numbers of passengers directly to strategic points within the heart of the business district.

Because subway operation is entirely separate from all other forms of traffic, and unaffected by climatic conditions, a very high degree of service regularity can be achieved.

Speed will be well over double that which can be performed on surface streets. Rush hour travel time savings afforded by use of the proposed initial subway are illustrated by the following table:

POTENTIAL TIME SAVINGS WITH PROPOSED SUBWAY

Trip		Traveltime in Minutes		Time Savings	
From	To	Present	With Subway	Minutes	Percent
Snowdon Junction.....	Place d'Armes.....	40½	27½	13	32.1
Decarie & Sherbrooke.....	Victoria Square.....	27½	18	9½	34.5
Bannantyne & Woodland....	St. Denis & St. Catherine...	41	29	12	29.3
St. Denis & Crémazie.....	The Forum.....	51	19½	31½	61.8
St. Denis & Jean Talon.....	Place d'Armes.....	31	10	21	67.8
Papineau & Bélanger.....	Windsor Station.....	41	24½	16½	40.2

The location and extent of the proposed initial subway is such that benefits will be afforded to most users of public transportation whether or not they use the subway. Substantial time savings will be realized by those who use the subway. In addition, however, reduction in number of transit vehicles operating on the surface in the central area will mean faster trips for those who use such surface vehicles.

Passengers using the subway will enjoy protection from the inclement weather. Passengers transferring between buses and subway trains will be provided convenient sheltered facilities at the two terminals and at all other locations where conditions permit.

Traffic congestion will be relieved in the central business district and on the major streets from which transit passengers will be drawn to the subway. This will benefit users of both private passenger vehicles and commercial trucks. The additional street capacity thus made available for private transportation could well exceed that which might be obtained by a street widening program.

SUBWAY OPERATION

The initial subway is expected to serve about 400,000 passengers for all or part of their journeys each day. Passenger traffic in the subway may be divided into four main categories as follows:

- (a) Passengers travelling between downtown stations (Dominion Square, Victoria Square, Place d'Armes, Champ-de-Mars, St. Catherine — de Montigny); and stations on St. Denis Street north of St. Catherine Street;
- (b) Passengers travelling between downtown stations and the Guy Street and Atwater Avenue stations;
- (c) Passengers travelling between the various stations on St. Denis Street north of St. Catherine Street; and
- (d) Passengers travelling between the three downtown stations (Victoria Square, Place d'Armes, Champ-de-Mars) and the Dominion Square and St. Catherine — de Montigny stations.

Of these principal passenger movements, (a) will be the greatest during most hours of the day. The service to be operated in the entire initial subway, therefore, has been designed to meet the requirements at the maximum load point just north of the St. Catherine — de Montigny station on St. Denis Street. See Plate 21.

Service will be provided as follows in each direction through each station:

<u>Period</u>	<u>Trains Per Hour</u>	<u>Interval Between Trains</u>
5:00 A.M. - 6:00 A.M.....	10	6 Minutes
6:00 A.M. - Midnight	20	3 Minutes
Midnight - 1:00 A.M.....	20	3 Minutes
1:00 A.M. - 3:00 A.M.....	10	6 Minutes

The length of the trains will vary at different periods of the day, being either four, six or eight cars as required.

All trains will be operated by a motorman and a guard. The duties of the latter will be confined to the operation of train doors and general supervision of entry and exit of passengers. All fares and transfers, of course, will be collected before passengers board the trains. Platform attendants will be stationed at various points during busy periods.

Overall running time between terminals has been scheduled at 24 minutes, an average speed of 19 miles per hour including stops at all stations. Average speed, exclusive of time at rest in stations, will be 24 miles per hour. Maximum speed trains may attain between stations is about 45 miles per hour, but all facilities are designed for safe operation at 50 miles per hour.

MODERNIZATION OF SURFACE SYSTEM

The Commission's announced policy of replacing streetcar services with autobus or trolleybus services, is already under way with the conversion, in 1952, of three major tram routes, i.e.; St. Catherine Street between Harbour and Viau Streets; Frontenac and Iberville Streets; and St. Lawrence Boulevard. Plans for 1953 include the replacement of streetcars by buses on St. Denis Street. It is expected that the entire program will be completed in about ten years. If the subway is undertaken, however, and substantial numbers of passengers are carried underground, the removal of streetcars from the streets will be much more rapid, inasmuch as fewer replacement vehicles and surface facilities will be required.

Many parts of the surface bus system would, of course, be designed to function with the subway, and routes would radiate from subway stations for the local distribution of subway passengers. Bus routings would be designed so that as many passengers as possible could utilize the subway for part of their journey. Buses would not be subject to delays in the central congested business district, since they would operate for the most part in areas outside the congested area and have the outer subway stations as their focal points. The subway would operate, unimpeded, as a high capacity collector and distributor of passengers in the central district.

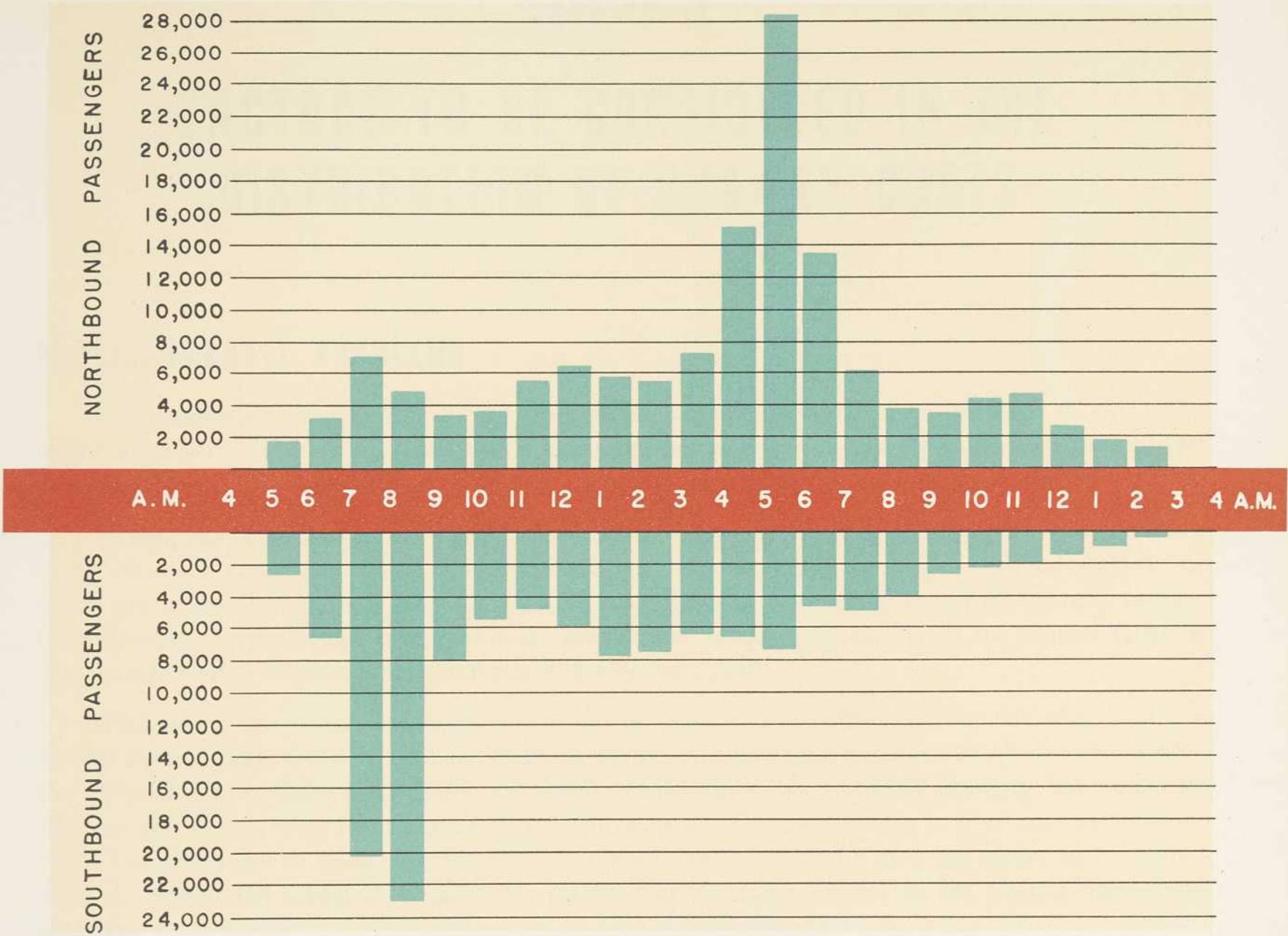
Exhibit 26 indicates a possible rearrangement of existing surface routes to function with the initial subway. This plan is designed on the basis of existing streets suitable for public transportation. It recognizes, however, the existence of Metropolitan Boulevard and Dorchester Street projects. No attempt has been made to predict other future changes in surface transit routing resulting from normal expansion or unforeseen circumstances.

This exhibit also portrays the general areas where a time saving of from 15 to 45 percent will accrue to passengers travelling to or from Place d'Armes. It will be noted that the initial subway, in conjunction with the revised surface routes, will benefit large areas of the City and adjacent municipalities.

Whether in conjunction with a subway or not, all modern techniques which are applicable to Greater Montreal will be employed in modernizing the surface system and expanding it to serve the increasing population. The Commission has studied and will continue to study other types of surface transportation, such as express service. The possibilities of express bus service in Montreal are very limited. Narrow streets, steep grades, traffic congestion, and climatic conditions are not conducive to this type of public transportation service. Furthermore, the speed of operation is being governed more and more by traffic slow-downs, cross-traffic and intersection delays, rather than by the number of passenger stops made.

It is the aim to provide a service that will attract to public transportation many who now use automobiles for daily travel to and from work in the central area. It is proposed, also, to establish ample parking lots in the neighbourhood of both subway terminals by acquiring adjacent lots. Motorists may then use the subway for part of their journey, avoiding the difficulties of driving and parking in the business section.

ANTICIPATED NUMBER OF PASSENGERS PER HOUR AT A POINT
IMMEDIATELY NORTH OF THE ST. CATHERINE – DE MONTIGNY STATION
ON A TYPICAL WEEKDAY



PROJECTED WEEKDAY SERVICE IN EACH DIRECTION

APPROXIMATE PERIOD OF DAY	NUMBER OF CARS PER TRAIN								INTERVAL BETWEEN TRAINS IN MINUTES							SEATS PER HOUR	TOTAL CAPACITY PER HOUR
	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7		
5:00 – 6:00 AM																2,400	7,200
6:00 – 7:00 AM																4,800	14,400
7:00 – 9:30 AM																9,600	28,800
9:30 – 4:30 PM																7,200	21,600
4:30 – 6:30 PM																9,600	28,800
6:30 – 1:00 AM																4,800	14,400
1:00 – 3:00 AM																2,400	7,200
3:00 – 5:00 AM	NO OPERATION																

PASSENGER VOLUMES AND TRAIN HEADWAYS
IN THE INITIAL SUBWAY

CHAPTER IX

FACTORS TO BE CONSIDERED IN THE DISTRIBUTION OF SUBWAY COSTS

PUBLIC TRANSIT PROBLEMS

Any adequate understanding of the problem of financing rapid transit subways or any other major addition to the transit facilities in metropolitan centres necessarily must be based on an understanding of the conditions surrounding all public transit operations during the last generation.

All large metropolitan areas in North America have been growing during the past three decades, many of them vigorously. Most of the growth has been experienced in the outlying sections of urban areas and in suburban communities. Not only have new residential and commercial centres been developed rapidly, but industries have sought new locations remote from the central areas to gain cheaper land, improved surroundings and reduced taxes.

While there have been increases in the use of private automobiles during the rush hours in United States cities, the diversion of traffic to motor cars has been proportionately greater during the off-peak hours. Rush hour traffic on public transit lines has remained more or less constant, whereas travelers during the off-peak periods have used their automobiles in ever increasing numbers. The shrinkage in passenger volumes on transit lines during the off-peak hours as compared with the rush hour volumes is constantly growing in the large centres in the United States and Canada.

The competing motor vehicle has added to the traffic streams to the point where severe congestion is the rule on most transit routes. The moving vehicles have slowed down traffic speeds — but worse still are the obstructions to free movement of buses and streetcars resulting from curb parking.

It is obvious that all of the foregoing developments have had an adverse effect on the financial problems of public transit operators.

Passenger traffic is constantly decreasing. However, personnel, plant, and equipment adequate to furnish suitable service during the morning and evening rush hours are still required. The investment in plant and equipment has not decreased. As a matter of fact, renewals and extensions require increased outlays of capital due to the inflationary spiral experienced since 1945. The investment in plant has increased but its use is now becoming more and more limited to the morning and evening rush hours. Thus the plant is only partly utilized during some eighteen hours of the day.

Restrictive labor agreements impose heavy burdens on operators. The abnormal variations between rush hour and off-peak traffic have been a headache to schedule makers who face the impossible task of writing schedules which will permit economical operation.

Present day financial difficulties are common to all transit operators — private and public.

Gradual decreases in passenger traffic produce decreases in net earnings. Operators constantly strive to improve transit service and at the same time effect economies which will produce a decrease in expenses proportional to the decrease in revenues — an impossible objective.

The inflationary spiral experienced during the past ten years has resulted in constantly increasing operating and maintenance expenses. The only recourse has been periodical increases in fares and these have been made by every operator, public or private, in both Canada and the United States. Unfortunately, such fare increases produce further losses in passenger traffic so that the public transit operator today is enmeshed in two spirals:

First — decreasing number of passengers,

Second — increasing maintenance and operating expenses.

These financial problems are common to all public transit system — whether privately owned or owned by a public agency. They exist on all urban operations in United States and Canadian cities, large or small.

During recent years, there seems to have come about a much greater understanding of the problems of public transit operators and a recognition on the part of citizens and public officials of the need for the maintenance of that degree of financial stability which will keep these all-important properties in first class condition.

As the result of the many problems summarized above, it may be said that private enterprise is gradually withdrawing from the public transportation field. The numerous hazards and the limited returns provide no incentive to invest capital. Public agencies — either the municipality itself or a special authority or commission — have been found to be the only solution in Chicago, Cleveland, Detroit, San Francisco, Seattle, Toronto and here also in Montreal. New York City owns its own rapid transit system and a number of surface lines and recently a public transit authority has been created to take over all of these publicly owned transit facilities. Transit is owned and operated by public transportation agencies in all cities in England having a population of one million or more. Paris transit has been publicly owned and operated for a number of years. The owners of private corporations operating public transit in most of the large cities of the United States have publicly stated their inability to cope with these increasing problems and many have offered their properties for sale to the public.

It would appear from the foregoing that a fair and reasonable division of the burden of raising and supporting the large capital investments required for rapid transit subways must be devised to avoid the imposition of an impossible load on the operators of transit systems and through them — upon passengers using their services.

ENHANCEMENT OF REAL ESTATE VALUES DUE TO RAPID TRANSIT LINES

Experience in all cities of the North American Continent has conclusively demonstrated that the construction of a subway and major transportation improvements produce enormous increases in real estate values. It is interesting to refer to studies made in Toronto, in New York and in Philadelphia on this point.

Toronto

The effect of the building of the Yonge Street subway in Toronto on land values was the subject of a detailed study by one of Toronto's outstanding real estate experts, Mr. Murray Bosley, who summarized his findings in a letter dated January 21, 1953, quoted in part below:

"Certain dramatic increases in value have come to our attention which we can attribute to the Rapid Transit scheme, particularly immediately adjoining sites established as station locations. Especially is this so at the north terminus in the vicinity of Eglinton Avenue and Yonge Street. Prior to the Rapid Transit System the four corners of Eglinton Avenue and Yonge Street supported a cigar store, bank, second-rate restaurant, and a vacant lot. Now the vacant lot is to be used by the Rapid Transit for a station, the cigar store location now supports a first-class retail store, the second-rate restaurant has now made way for Tamblyn's, Kresge's, and other first-rate chains, and the bank is now flanked by substantial buildings. All vacant land within 500 feet of the corner has been either developed or purchased for development at rates as high as \$1,000 per foot.

"Specifically, one site which was purchased in 1947 at \$8,500 was sold in 1952 for \$100,000, the site having a frontage of approximately 90 feet. This site is to be used for the development of a Physicians & Surgeons building.

"At Yonge Street and St. Clair Avenue land values which were on the order of \$200 to \$300 a front foot prior to the expropriation have recently reached a peak of \$1,600 a foot.

"At Yonge and Bloor Streets great developments are just now commencing in the form of new head office buildings for the Crown Life Insurance Co., The Confederation Life Insurance Co., and The Independent Order of Forresters. All these developments are taking place on lands acquired since the Rapid Transit scheme was decided upon and formerly used for residential purposes.

"The whole of the Bloor Street frontage from Yonge to Sherbourne Street is now developing as a financial and business district; this frontage was, until the advent of Rapid Transit, largely a dormant area.

"In the area lying south of Bloor to College Street, land adjacent to stations of the Rapid Transit is being rapidly acquired by interests formerly located in the downtown section, we ourselves having recently purchased property on Wellesley Street East at almost twice the price which these lands commanded a couple of years prior to our acquisition. We expect this type of interest to continue. Many firms located in the downtown area do not, of necessity, need to be in the central parts of the city. The easy access to downtown by means of the Rapid Transit and the improved parking facilities are factors which have caused this migration.

"This same area will shortly see the commencement of large apartment house projects which are well past the planning stage, as well as the erection of at least one substantial new hotel."

New York City

The completion of the first subways in New York about fifty years ago provided an excellent opportunity for a realistic appraisal of the enhancement of real estate values produced by rapid transit subway construction and operation. This was the subject of a rather detailed study made by the City Club of New York published about four years after the completion of New York's first subway. The survey took into consideration the normal increases in land values as measured throughout New York City and utilized for this purpose the increase in values experienced over a seven-year period just prior to the turn of the century.

They found that rather spectacular increases in real estate values over and above the normal rise had been developed, particularly in the upper section of Manhattan Borough and in The Bronx. In Manhattan Borough, in the area north of 79th Street, abnormal rises in values, which the City Club attributed to the subway, ranged from 43 percent to 104 percent. In a portion of The Bronx, the abnormal enhancement due to subway construction was appraised at an average of 77 percent.

Philadelphia

The report of A. Merritt Taylor, Transit Commissioner of the City of Philadelphia, contains an analysis of the effect of the construction of the Market Street subway on real estate values. This study was of special interest in that it measured the increase in real estate values in the downtown business district prior and subsequent to the construction of the Market Street subway.

The Market Street subway began operation in August 1908. The Taylor report appraised the increase in land values along Market Street at 128 percent, while during the same period similar real estate on Chestnut Street (one block to the south) increased by only 26 percent and that on Arch Street (one block to the north) by 39 percent. The foregoing percentages are applied to total values of buildings and lands.

This report also dealt with increases in values of unimproved property in West Philadelphia prior to and subsequent to the construction of the Market Street subway-elevated line. This study showed an enormous enhancement in value of land in outlying and undeveloped districts amounting, in a 12-year period, to over 500 percent.

Similar experiences are repeated in nearly all places where a rapid transit system has been established. Identical conditions occur in all large cities of the North American Continent.

GENERAL BENEFITS ACCRUING FROM A RAPID TRANSIT SYSTEM

Throughout this report references have been made to the benefits to be derived from the proposed subway. These benefits are listed briefly below:

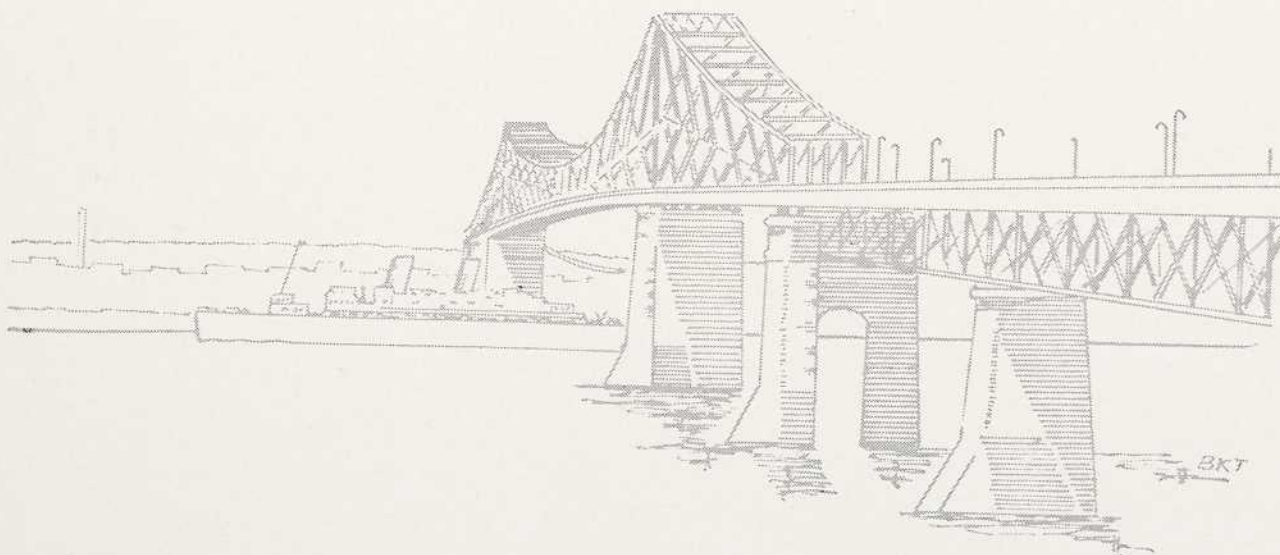
1. The ability to transport 40,000 passengers per hour into the central district and also to transport 40,000 passengers per hour from this district, during morning and evening rush periods.
2. The speed of transit vehicles is unaffected by snow storms, rain or any adverse climatic conditions.
3. Regularity of service permitting every passenger to reach his place of work without delay.

4. Saving of time for public transportation passengers, who represent 70 percent of all persons travelling
5. Subway stations and bus terminals protect passengers against inclement weather.
6. The stabilization of, and the increase in, the value of real estate adjacent to the subway, as well as in remote areas made more accessible by the subway.
7. Improved access to all commercial and industrial establishments in the heart of the city.
8. Sound growth of commerce and industry encouraged by improved transportation facilities.
9. Reduction of traffic congestion in the heart of the city by the decrease in number of surface transport vehicles, and street traffic relief permitting automobiles and trucks to move about more rapidly.
10. Saving of time and money for businesses and industries resulting from more rapid movement and delivery of materials and of merchandise.
11. Reduction in number of traffic accidents.

CONCLUSIONS

In the next chapter, which deals with the distribution of subway costs, the three factors discussed in this chapter should be kept in mind:

- (a) The problems of public transportation;
- (b) The increase of real estate values accruing from a rapid transit system;
- (c) The general benefits derived from a rapid transit system.



CHAPTER X

ESTIMATE OF COST AND FINANCING OF THE INITIAL SUBWAY

PROJECTED SURFACE IMPROVEMENTS

Improvements projected at this time in metropolitan Montreal include completion of the modernization of the existing system. In addition, the Commission is now presenting a report on the establishment of a rapid transit system.

The Montreal Transportation Commission faces a real problem in financing the modernization of its extensive public transit system. The conversion of the entire electric street railway system to rubber-tired operation will require the purchase of new rolling stock involving millions of dollars of new capital. Moreover, new garages and changes in the existing maintenance and repair shops, and storage facilities are required to accommodate the large, modern fleet of trolley and motor buses. The funds necessary for this modernization will be in addition to any contribution the Commission may be called upon to make in connection with the building of rapid transit subways.

ESTIMATE OF COST OF INITIAL SUBWAY

Basic Data

A vast amount of basic data covering topography, street grades, sewers, water mains, and other city-owned facilities was made available through the cooperation of the Department of Public Works of the City of Montreal. Thorough records of the location and character of all electric power, telephone, gas, and other underground facilities have been maintained and were furnished for our use by the several public and private agencies owning and operating them.

Plans covering buildings, building foundations, and sub-sidewalk vaults were available for a major portion of the rights-of-way required for the proposed initial subway as well as for most structures abutting on the streets along the subway route. These data were made available on a loan basis by numerous public spirited architects, engineers, and owners of buildings. To the extent necessary, preliminary field surveys were conducted by engineers of the Commission's staff to supplement and in some cases to confirm the accuracy of the data made available by all of the foregoing cooperating agencies.

The extensive underground explorations conducted by the Commission are described in detail in a separate publication entitled "Appendix C", which will be available upon request to the cooperating agencies for their review and file. This volume contains a complete record of all of the test pits and borings, as well as soils analyses and the records of the ground water levels which have been maintained since the making and completion of the borings. All soil and rock samples have been preserved and stored.

Preparation of Estimates

The estimate of cost has been set up on a unit basis developed for ultimate use in the preparation of contract documents. Available for reference were all of the unit and total costs of the several subway contracts in Chicago and in Toronto; the latter covering all work on the Yonge Street subway now being completed. The necessary adjustments have been made in both cases to bring these costs to the January 1953 price level.

Independent estimates were also made by two well known construction experts who have had extensive experience in heavy construction, including tunnels and subways. The independent estimates of these experts were prepared in considerable detail and were based on the use of all of the data mentioned above.

These independent estimates were then reviewed by our staff and final figures adjusted after a study of the variations which appeared in certain items. The summary of total estimated cost of the project, which follows, covers the principal component parts of the project and is based on cost of material, equipment, and labor rates prevailing in January 1953.

An allowance for engineering and contingencies has been added equal to approximately 20 percent of the estimate of construction costs for the subway structure. Previous experience indicates that engineering costs amount to about 7-1/2 percent of the construction costs, leaving approximately 12-1/2 percent for contingencies. About 17 percent has been added to the estimated cost for rights-of-way to cover overhead expenses and contingencies; for fixed transit equipment, the percentage added for engineering and contingencies is about 16-1/2 percent; and for subway cars approximately 14 percent.

The cost of underpinning adjacent buildings has been estimated after the preparation of preliminary plans covering the several types of underpinning required. Records of water levels, which have an important bearing on underpinning costs, were studied carefully prior to the making of the final estimates. Underpinning methods and estimates of cost have been checked and approved by an expert who has specialized in this type of work for more than forty years.

The estimate includes the costs of rights-of-way and easements, and also the estimated value of the air rights which will be available for sale after the completion of the proposed subway.

A separate volume entitled "Estimate of Costs for the Initial Subway" (see Appendix B) has been prepared, which contains in detail the calculations of quantities and costs for the complete project. The items of work and procedures involved in each of the units set up in these estimates and for ultimate use in the preparation of contract documents are also described in this volume. All data as to costs will be kept in the records of the Commission and can, at any time, be adjusted to the variations in the costs of labour and materials.

Referring to the total estimated cost of \$117,000,000 for the initial subway, it will be noted that this total figure is comprised of two parts: Part A, which may be called the subway structure, amounts to \$87,000,000 and represents the outlay required to build the subway proper, and does not provide for any of the fixed equipment necessary for its operation as a transit facility; Part B, amounting to \$30,000,000, represents the capital expenditure estimated for fixed transit equipment and subway cars to provide mass transportation.

SUMMARY OF ESTIMATE OF COST OF INITIAL SUBWAY

PART A

Subway Structure

Cut-and-Cover Sections.....	\$34,815,000	
Rock Tunnel Section.....	18,719,000	
Earth Tunnel Section	2,604,000	
Station Finish — Underground.....	1,466,000	
Above Ground Stations.....	511,000	
Public Utilities — Maintenance and Restoration.....	5,876,000	
Underpinning Adjacent Buildings.....	3,068,000	
Streetcar Track Restoration.....	58,000	
Paving	290,000	
Ventilation	260,000	
Escalators	926,000	
Pumps	77,000	
Subway Lighting.....	784,000	
Total	\$69,454,000	
Engineering and Contingencies.....	13,546,000	
Total Cost of Subway Structure.....		\$83,000,000

Rights-of-way

Estimated Cost of All Properties and Easements.....	\$ 6,420,000	
Overhead Expenses and Contingencies.....	1,080,000	
Total	\$ 7,500,000	
Less Estimated Net Value of Air Rights.....	3,500,000	
Net Cost of Rights-of-Way.....		\$ 4,000,000
Total Cost of Subway and Rights-of-Way.....		\$ 87,000,000

PART B

Fixed Subway Equipment

Youville Service and Repair Shops.....	\$ 1,652,000	
Shop Equipment.....	63,000	
Subway Station Equipment.....	108,000	
Subway Tracks.....	2,576,000	
Third Rail.....	1,550,000	
Substations, Power Transmission, and Appurtenances	4,515,000	
Signals and Interlocking.....	2,405,000	
Total	\$12,869,000	
Engineering and Contingencies.....	2,131,000	
Total Cost of Fixed Transit Equipment.....		\$15,000,000

Subway Cars

160 Cars at \$82,000.....	\$13,120,000	
Engineering and Contingencies.....	1,880,000	
Total Cost of Subway Cars.....		\$15,000,000
Total Cost of Equipment.....		\$ 30,000,000
Grand Total.....		\$117,000,000

THE DIVISION OF THE COST OF THE SUBWAY BETWEEN THE GENERAL PUBLIC AND THE USERS OF THE PUBLIC TRANSPORTATION SYSTEM

The Commission has undertaken a thorough study of the methods of financing existing subways, as well as the financial results of their operation. We have come to the conclusion that it is futile to think that the passengers of the transportation system alone could absorb the considerable capital costs which the construction and equipping of a subway would require.

The Commission has examined in what manner, in all fairness, the cost of a subway could be divided between the public in general and the users of the transportation system.

To encourage and to assure the progress of Greater Montreal, a subway is of primary importance. The advantages are widespread, not only to the users of the transportation system, but to all citizens as well as commercial and industrial enterprises.

No other factor would exercise such a determining influence on the value of real estate, which would not only be stabilized but would be increased. The revenues of the municipalities would grow in the same proportion.

A transportation system is vital for a metropolis. In all large cities of the world, experience shows that when it is impossible to transport a large number of citizens rapidly and conveniently, real estate values in congested districts have a tendency to decline. In order to conduct business it is absolutely necessary to have easy access to the commercial houses and industries — they cannot survive otherwise.

One of the reasons why most of the great cities of the world have undertaken the construction of subways, is the necessity to safeguard the very existence of the most important part of their territory and to encourage the residential, commercial, and industrial expansion of their periphery. This is the conclusion which must be reached after reviewing the causes which led to the building of the existing subways, notably those of Paris, London, Berlin, Buenos Aires, New York, Chicago, Philadelphia, Boston, Cleveland, and Toronto.

From the point of view of improvement of transportation and of traffic, a subway would provide the most advantages to the greatest number of people per dollar spent. It must not be forgotten that about 70 percent of the persons carried in the central district of Montreal during rush hours by various types of vehicles, use trams, autobuses, and trolley buses.

The necessity for a subway is a direct consequence of the expansion of Greater Montreal, by reason of the increase of its population as well as the growth in number and importance of its commercial and industrial enterprises. The construction of a subway would contribute greatly to its continued progress and prosperity.

The Commission is of the opinion that it is incumbent on the City of Montreal and on the municipalities of the metropolitan district to furnish the streets necessary for the transportation of its population. Considering the construction and maintenance of a subway to be comparable to a double level street — which would permit the separation of public transportation vehicles of large capacity from all other vehicles — the Commission believes that the cost of construction and maintenance should be borne by the general public. This cost of construction (\$87,000,000) is outlined in detail in Part A of the estimate, and includes the items mentioned under the titles "Subway Structure" and "Rights-of-Way".

In its report to the Lieutenant-Governor in Council, dated August 1950, on the question of the Montreal Tramways Company, the Board of Arbitration, presided over by Judge Thomas Tremblay, in the ninth chapter relating to the subway, concludes as follows:

"We have sought, in the history of these cities, a means of financing the subway which it is proposed to build in Montreal. Everywhere the opinion seems to be generally accepted that the costs of building a subway are so enormous that they can not be supported by those using it but that they will have to be paid as taxes, like any other municipal public works such as roads, pavings, sewers, waterworks, etc."

The Commission is also of the opinion that the City of Montreal should not carry alone the cost of the subway but that it should be divided between the municipalities comprising the metropolitan district at the time of its construction. As to the distribution of the cost of \$87,000,000 between the different municipalities, the Commission does not consider that this question lies within its jurisdiction.

The Parliament of Quebec, at its 1952-1953 Session, passed an Act (15-16 George VI, Chapter 65, Article 9) authorizing the Council of the City of Montreal to create by by-law, a body designated under the name "Commission for the Study of the Metropolitan Problems of Montreal", to study the administrative problems resulting from the existence on the Island of Montreal, of several cities, towns or other municipal corporations, neighbouring or contiguous, certain of which are surrounded by the territory of the City of Montreal.

The City of Montreal has created this Commission of study, by by-law No. 2079, adopted on the 10th November 1952, as amended by by-law No. 2089, adopted on the 4th February 1953. The City of Montreal and all of the municipalities of the actual metropolitan district are represented on this commission. The law provides that:

"This Commission shall study the administrative problems resulting: from the existence, on the Island of Montreal, of several cities, towns or other municipal corporations, neighbouring or contiguous, certain of which are surrounded by the territory of the City of Montreal; from the fact that the latter, while forming an economic and geographic whole, are submitted to different and independent administrative systems; from the practical impossibility, for certain of them, to organize adequately on a local basis various essential public services or those of a metropolitan nature; from the unequal distribution and, in certain cases, the complete absence of distribution of the cost of services, works and improvements of benefit to all; of transportation by taxi; generally from the administrative relations between these various cities and towns and municipal corporations."

This Commission is under the chairmanship of Judge Roland Paquette, Judge in Chief of the Municipal Court of Montreal. A general and final report is to be submitted to the City of Montreal before June 1, 1954.

As noted above, this Commission must study the administrative problems relating amongst others:

"From the practical impossibility, for certain of them, to organize adequately on a local basis various essential public services or those of a metropolitan nature; from the unequal distribution and, in certain cases, the complete absence of distribution of the cost of services, works and improvements of benefit to all."

THE PUBLIC TRANSPORTATION SERVICE

The transportation system of the Commission at present serves Montreal and sixteen neighbouring municipalities, permitting the movement of people within the whole metropolitan area. They all benefit from the entire transportation system of the Commission and particularly from the services in the centre of Montreal, encouraging access to Federal and Provincial Government offices, law courts, the registry office for the Montreal district, head offices of the great financial and industrial institutions, professional firms, docks and other establishments of the Port of Montreal, wholesale grocers, the large retail stores, the principal hotels, theatres, places of amusement, et cetera. In addition to this, many people come from outside municipalities to work in the centre of Montreal; others must cross it to reach their daily tasks in another municipality. The transportation service is essential to the whole metropolitan district; it possesses, therefore, a metropolitan character and could not be organized in a practical and efficient manner by each of the municipalities served. Finally, it results clearly from this outline that the subway, in becoming a part of this transportation system, would benefit each and every municipality.

The division of the cost of the construction and maintenance of the subway between all these municipalities will stem, no doubt, from the general principles which will be laid down in the report of the Commission on metropolitan problems in their entirety. The Montreal Transportation Commission cannot interfere with the prerogatives of this Study Commission. We are, however, ready to assert that the initial cost of the construction of the subway, amounting to \$87,000,000 should be divided between all the municipalities of the metropolitan district; that they should all assume responsibility for the loans to be effected; and that the amounts of interest and of amortization should be divided between them on a pro rata basis to be determined.

As to the financial problems involved, it is incumbent on competent authorities to decide when the project becomes feasible. For the purposes of our report, we shall examine what would be the annual cost to the municipalities resulting from the construction of the initial subway proper.

In view of the permanent character of the investment in rights-of-way and in steel and concrete construction, amortization over a period of fifty years would be reasonable. For a serial bond issue of \$87,000,000 bearing interest at the rate of $4\frac{1}{2}$ percent, it would require approximately \$4,400,000 per annum to cover interest charges and to provide for the full retirement of the debt over a period of 50 years.

The annual revenues of the municipalities forming part of the Metropolitan Commission are presently approximately \$100,000,000 per annum, school taxes excluded. The additional cost of \$4,400,000 per annum for the construction of that part of the initial subway which should be borne, according to our opinion, by the public in general, would require a total revenue of \$104,400,000 instead of \$100,000,000.

There is no doubt that the increased revenues to the municipalities resulting from the appreciation in value of real estate, the upsurge in commercial and industrial progress in Greater Montreal, the economy of time resulting in the saving of money for the great majority of the people, and all the advantages enumerated in Chapter IX resulting from the construction of a subway, would amply compensate for this additional expense of \$4,400,000.

CAPITAL EXPENDITURES WHICH SHOULD BE BORNE BY THE USERS OF THE PUBLIC TRANSPORTATION SYSTEM

We estimate at \$30,000,000 these capital expenditures required for putting the initial subway into operation. For details, see Part B, Summary of Estimate of Cost of Initial Subway.

The subway would constitute the backbone of the transportation system; it would function in conjunction with the surface lines in such a manner that the whole would form a unified system permitting all citizens of the metropolitan district to travel in an economical, practical and rapid manner.

Before a single subway car can be routed through the subway there must be provided and installed tracks, third rail, power distribution and control, signals, communication and emergency alarm systems, as well as storage facilities, and maintenance and repair shops; all involving a total outlay of \$15,000,000. Modern rapid transit cars will cost an additional \$15,000,000 making a total investment of \$30,000,000.

The equipment represented by this capital expense of \$30,000,000 will serve solely for the transportation of passengers and the Commission believes that the cost should be borne by them.

It is impossible to establish now the operating costs of a public transportation system, comprising the initial subway and the surface lines necessary at the time of completion of the initial subway. The essential operating data necessary for so doing can only be known at the time the subway is undertaken.

Today, the transportation system comprises tramways, autobuses and trolley buses. We have a funded debt of about \$43,000,000, of which a part represents the assets of the tramways system. This debt will gradually be reduced in the course of the coming years through the operation of sinking funds.

On the other hand, we have started a programme of modernizing the surface system by substituting autobuses for tramways, a programme which will be followed as regularly as financial conditions permit. The purchase of this new equipment and the construction of new garages, will necessitate important additional borrowings, which will be negotiated successively as these substitutions progress. The initial subway, if built in the near future, will exercise a determining influence upon the speed of this transformation.

We can, however, estimate the probable operating costs, under existing conditions, of the initial subway combined with autobus and trolley bus routes functioning with the subway and compare them with the operating costs of the surface system alone, as it presently exists.

Consequently, we have made a thorough study of the total operating costs of the existing surface system by tramways, autobuses and trolley buses for the 12-month period ended March 31, 1953, and what would have been the cost for the same period, of a system comprising the initial subway

combined with a complimentary autobus and trolley bus service as described in this report. As far as it may be possible to calculate the expenses of the combined subway, autobus and trolley bus system, together with the interest costs (including interest on the \$30,000,000 hereinabove referred to) and depreciation, the additional annual cost that the users of the transportation system would have had to absorb for this period would have been in the order of \$2,200,000.

This \$2,200,000 increase in expenses for the period above-mentioned, divided among the 368,000,000 passengers which we presently carry, would have meant an increase of about six-tenths of one cent per ride to the existing fares for the present surface transportation system.

We do not know when this initial subway will be built; neither do we know what fares will be in force at the time of its construction. The comparative figures of these annual operating costs cited above for the two systems will necessarily have to be adjusted in accordance with the conditions then existing.

We hold the conviction that the savings in money resulting from the time saved by the users of the transportation system in their daily movements would greatly exceed this fraction of a cent which they would be called upon to pay for each ride. We therefore recommend that the Commission accept responsibility for that part of the capital outlay, amounting to \$30,000,000, necessary to furnish and install the operating equipment in the subway.

Respectfully submitted,

A. DUPERRON,
Chairman and General Manager,

RICHARD F. QUINN,
Vice-Chairman,

LÉONARD LÉGER,

C. A. SYLVESTRE,
Commissioners.

MONTREAL, JUNE 1953.