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SOVIET HYDROLOGIC PLANNING

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PREPARED UNDER THE DIRECTION OF THE
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DEPARTMENT OF THE ARMY
OFFICE, CHIEF OF ENGINEERS
WASHINGTON 25, D. C.

ENGINEER INTELLIGENCE STUDY 245

SOVIET HYDROLOGIC PLANNING

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ABSTRACT

1. This report is an analysis of the hydrologic planning in the U.S.S.R. for development of water resources, as related to the over-all economic, strategic, and political objectives of Soviet policy.

2. The study examines the hydrologic features of the U.S.S.R., and the planning and construction programs for water resource development in relation to the general development policies of the Soviet Union. The two major plans for water resource development, the Great Volga Development and the Davydov Plan are analyzed, and the present and possible future trends are evaluated.

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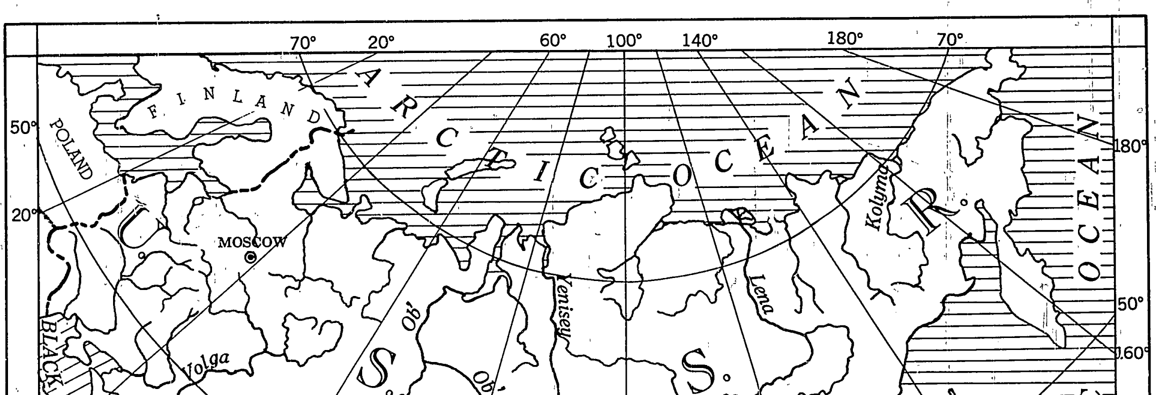

AREA OF STUDY

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SECTION I

INTRODUCTION

1-01 PURPOSE AND SCOPE

a. The purpose of this EIS is to analyze the hydrologic planning of the U.S.S.R. for development of its water resources, as related to the overall economic, strategic, and political objectives of Soviet policy.

b. The study examines the hydrologic features of the U.S.S.R., and the planning and construction programs of water resource development since the establishment of the Soviet regime in 1917. It appraises these programs in relation to general development policy and objectives and evaluates the possible future trends of water resource planning and its implementation.

c. The study is based upon numerous Soviet, French, and German books, pamphlets, and articles in periodicals, the most important of which are listed in the bibliography. Most of the sources were collected as a private research project over the period 1953 to 1958 by an individual member of the Army Map Service.

1-02 ABBREVIATIONS

The abbreviations of dimensional terms used are as follows:

cm	centimeters
km	kilometers (distance)
km^2	square kilometers
km^3	cubic kilometers
Km	kilometer (river location)
kw	kilowatt
kw-hr	kilowatt hours
m	meters
m^2	square meters
m^3	cubic meters
mm	millimeters
m/km	meters per kilometer
m/sec	meters per second
m^3/sec	cubic meters per second
MSL	mean sea level

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SECTION II

HYDROLOGIC FEATURES OF THE U.S.S.R.

2-01 GENERAL

The character of the drainage pattern of the rivers of Russia has always exerted a tremendous influence upon the political and economic development of the country. The river drainage distribution of the whole Eurasian continent is its most distinctive characteristic, according to the geopolitical theory on the influence of geographic features on the formation of a nation's foreign policy. The Soviet Union in the "heartland" of the Eurasian continent occupies nearly 40% of the total area; the character of its rivers is described by the British geographer, Mackinder, as follows:

> Euro-Asia is characterized by a very remarkable distribution of river drainage. Throughout an immense portion of the centre and north, the rivers have been practically useless for purposes of human communication with the outer world. The Volga, the Oxus /Amu Darya/, and the Jaxartes /Syr Darya/ drain into salt lakes, the Ob, the Yenisey, and the Lena into frozen oceans of the north. These are six of the greatest rivers in the world. Thus the core of Euro-Asia is wholly unpenetrated by waterways from the oceans.

2-02 DRAINAGE PATTERN

a. General. Soviet rivers may be grouped in three categories according to the bodies of water into which they flow. Soviet rivers drain into: 1) the generally icebound ARCTIC Ocean, 2) the inland CASPIAN and ARAL Seas, and 3) the ice-free PACIFIC and ATLANTIC Oceans (Plates 1 and 2). The relative size of the drainage areas is as follows:

Drainage Areas Millions of km^2	Percent of Soviet Territory	Bodies of Water
11.7	54	ARCTIC Ocean
5.2	23	CASPIAN and ARAL Seas
3.2	15	PACIFIC Ocean
1.8	8	ATLANTIC Ocean

(1) Following are the mean yearly flow volumes and the lengths of the principal rivers of the U.S.S.R.:

River	Annual volume of flow (km^3)	Length (km)
ARCTIC OCEAN		
PECHORA	120	1,790
OB'-IRTYSH	394	3,676 (OB') 4,442 (IRTYSH)
YENISEY	548	3,354 (with ANGARA and SELENGA)
LENA	438	4,270
KOLYMA	120	2,600
CASPIAN SEA		
VOLGA	255	3,688

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River	Annual volume of flow (km^3)	Length (km)
ARAL SEA		
AMU DARYA	42	1,404
SYR DARYA	14	2,137
PACIFIC OCEAN		
AMUR	346	2,846
BALTIC SEA		
WESTERN DVINA	111	1,020
BLACK SEA		
DNIEPER	53	2,280
DON	28	1,970

(2) Arctic Ocean. The three largest Soviet rivers, the OB'-ITRYSH, YENISEY, and LENA, drain into the ARCTIC. Their combined annual flow is larger than the total annual flow of all the other Soviet rivers (see Plate 2). The frozen condition of the ARCTIC Ocean and of the lower reaches of the rivers cuts off this drainage area from communication with open ice-free oceans over much of the year.

(3) Inland Seas, Caspian and Aral. The VOLGA River and several so-called "lost rivers" drain into the CASPIAN and ARAL Seas. The flow of these "lost rivers," such as the AMU DARYA and SYR DARYA, is progressively absorbed in the sand of the TURAN steppes and deserts. The elevation in this area is as low as -86 m, MSL. It is an extremely arid region with an adverse hydrologic balance because annual evaporation rates tend to exceed precipitation. The dominant hydrologic feature of the area is the CASPIAN Sea, whose present surface area of 371,800 km^2 ranks it as the world's largest inland sea. The adverse hydrologic conditions, however, have resulted in a progressive lowering of its level since the middle of the 19th century. The vast hydraulic construction works built along the VOLGA in recent years have failed to arrest the sinking of the CASPIAN, and in fact have actually accelerated its sinking.

b. Topography. The topography of the U.S.S.R., in contrast to that of Central and Western Europe, consists of large, relatively flat areas delimited by mountain ranges, bisected by the URAL Mountains, and marked by some of the world's largest depressions. The natural division of the U.S.S.R. by the URALS into European and Asiatic areas also holds true in any discussion of drainage. In this EIS, drainage of the two regions of the country will be treated separately within the breakdown into the three categories mentioned above.

2-03 RIVERS, EUROPEAN U.S.S.R.

The rivers of the European U.S.S.R. radiate from low hills northwest of Moscow. The headwaters of all the major rivers in this area are thus close together, which facilitates interconnection by means of canals. The VOLGA drains the major part of the area and flows into the CASPIAN Sea. The DON, DNIEPER, and DNIESTER drain into the BLACK Sea. Other major rivers include the WESTERN DVINA and NEVA, which flow westward into the BALTIC Sea, and the NORTHERN DVINA and PECHORA, which flow northward into the ARCTIC Ocean.

2-04 RIVERS, ASIATIC U.S.S.R.

a. Arctic Ocean Drainage. The Siberian rivers that flow northward to the ARCTIC Ocean are marked by progressive eastward shifting of their beds as

a result of the earth's rotation. Their high discharges are generally the result of the heavy snowfall in the mountains of Southern Siberia. Melting of snow cover and thawing of river ice occur earlier in these headwater reaches than in the north and create great spring floods in all Siberian rivers. These spring flood conditions in the north are aggravated by permafrost conditions. (In Central and Eastern Siberia, floods occur in summer also, as a result of very violent, sudden thunderstorms.) Inundation along the lower reaches of the rivers covers vast areas. For example, floods along the lower reach of the YENISEY may rise 11 m and inundate areas up to 50 km wide. Because the rivers have a 1- to 2-m ice cover in winter, ice-breakup in the spring is violent and abrupt, resulting in the formation of great ice jams that intensify flooding. When the ice jams break loose, enormous blocks of ice are carried downstream with great erosive effect on the riverbeds. The period of ice cover and breakup averages from 210 to 219 days a year. Descriptions of the most important rivers that drain into the ARCTIC Ocean follow.

(1) Ob'-Irtysh System. the OB' River and its principal tributary, the IRTYSH, empty into the ARCTIC Ocean through the OBSKAYA GUBA, a gulf 800 km long, 35 to 60 km wide, and 10 to 22 m deep. They originate in the Central-Asiatic mountain chain at 4,000 m, MSL, and descend rapidly onto the Siberian plain.

(2) Yenisey River. The YENISEY River system includes the SELENGA River, Lake BAIKAL, and the ANGARA River. This system originates on the northern slopes of the Central Asiatic plateau of Mongolia at 2,000 m, MSL. At one time several MONGOLIAN lakes farther south also drained into the YENISEY, but this communication has become clogged by moving sand. Lake BAIKAL's surface area of 30,585 km^2 ranks it among the largest inland lakes of the world. It has an average depth of 810 m and a maximum depth of 1,742 m. The volume is 23,000 km^3 and the annual inflow, 55 km^3.

(3) Lena River. The LENA has two main tributaries, the VILYUY and the ALDAN, and flows into the LAPTEV Sea, an arm of the ARCTIC Ocean. It has 45 branches flowing through a delta 210 m wide.

b. Inland Sea Drainage. The rivers in this area flow generally northwest into the arid interior. Many are intermittent streams, and others dissipate eventually in marshes or desert sands. The largest rivers in the area, the AMU DARYA and SYR DARYA, drain into the ARAL Sea.

c. Pacific Ocean Drainage. The main Soviet river emptying into the PACIFIC is the AMUR; one of its tributaries, the ARGUN, originates northeast of the GOBI Desert in Outer Mongolia. Originally the system was much longer, but its headwater branches have dried up because of severe desert conditions. Its regime, particularly along its middle reaches, is influenced by monsoon rains. The winters in the region are cold, dry and almost entirely without snow. Ice breakup on the river starts in March, and ice jams and associated flooding are common occurrences. The AMUR empties through a gulf into the Sea of OKHOTSK, an arm of the PACIFIC Ocean.

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SECTION III

POLITICAL, STRATEGIC, AND ECONOMIC BACKGROUND

3-01 GENERAL

a. The vastness of Russia and its relative inaccessibility to the ice-free oceans of the world have always exerted a tremendous influence upon political, strategic, and economic developments. The utilization and development of the rivers and their role as waterways have always been key factors in these developments.

b. By 1917, appreciable work in construction of canals for waterway connections between the river systems had been accomplished, primarily to provide communication between the VOLGA River system and the BALTIC Sea. Since 1917, Soviet authorities have emphasized water resource development as an integral part of the economic and strategic program. Soviet plans and programs for water resource development are comprehensive and involve navigation, hydroelectric power, irrigation, drainage, and water supply.

3-02 TRANSPORTATION AND COMMUNICATION PROBLEM

a. <u>Limited Access to Ice-free Oceans.</u>

(1) Soviet territory, which occupies a sizable part of two continents, covers 22,400,000 km^2 and extends 10,000 km from the BALTIC to the PACIFIC. (By comparison, the United States covers only 7,400,000 km^2 and extends 4,500 km from the ATLANTIC to the PACIFIC.) This great size makes transportation and communications in the U.S.S.R. key elements affecting the entire economy. The low density of population, the remoteness of the widely scattered raw material resources from industrial centers, and the limited access to ice-free oceans further complicate the transportation problem.

(2) Limited access to the open seas has always been considered the most serious disadvantage of Russia's geographic location. Historically, striving for better access to ice-free oceans has always been a directing force in foreign policy. The 200-year conflicts with the Ottoman Empire were largely motivated by the struggle for free access to the MEDITERRANEAN Sea through the DARDANELLES; many of the perpetual differences with the British Empire were due to the striving for access to the INDIAN Ocean through the PERSIAN Gulf. The Tsarist Navy and merchant marine were poorly developed because of the control by other powers of the strategic narrows, such as the DARDANELLES, GIBRALTAR, and the SKAGERRAK. The ARCTIC was the only ocean freely available to Russia, but its adverse climatic and navigation conditions restricted its usefulness. For example, during the Russo-Japanese War, the Russian Baltic Fleet had to travel 34,000 km around the CAPE OF GOOD HOPE to join with the Russian Pacific Fleet. This delay, plus the similar difficulty in logistic support, was a major factor in the disastrous defeat by the Japanese fleet in the famous TSUSHIMA naval battle of May 1905, which eliminated Russia as a naval power.

(3) A second solution to the problem of access to ice-free seas has been the intensive utilization of the large network of navigable rivers. The factors involved in the use of rivers as a primary means of transportation are discussed more fully in the next paragraph.

b. <u>Rivers as Transportation Carriers.</u>

(1) As a transportation medium, rivers have played a vital role in the economic development of the country, particularly in the penetration and conquest of vast regions of Siberia and Central Asia where they have long represented the only practicable and dependable means of mass transportation.

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(2) Russia is well served by an extensive network of long navigable rivers. Their headwaters are close together and the drainage divides are low, facilitating connections by shallow canals or overland passages. River velocities are low as a result of the slight gradient; barges must generally be towed downstream as well as upstream. High spring floods, low summer stages, and a long frozen period limit the navigation period to between 150 and 200 days annually. However, even when frozen, the rivers are important for transportation as they provide ideal sledgeways. The taiga and tundra regions of Siberia are inaccessible except by rivers.

c. <u>Waterway-Railroad Transportation.</u>

(1) Although the construction of railroads began in Russia in 1837, their development was relatively slow because of many factors, such as the tremendous distances, low population density, low industrial development, and lack of adequate capital and skilled labor. The Soviet regime accelerated railroad construction and, by greatly increasing the utilization of the railways, has established rail transport as the principal means of haulage at the present time. However, this intensive utilization of the country's relatively sparse rail network is recognized as a hindrance to economic growth, and Soviet planners look to waterway development as the best means of improving their transportation system. (The role of highways in the transportation system of the U.S.S.R. is relatively minor; roads serve mainly as feeders to railways and waterways, and long truck hauls are virtually unknown.)

(2) Much of the railroad construction was directed mainly at complementing the waterway system, the railroads commonly serving as links to connect the waterways for long distance transportation. Such was the function of the Trans-Siberian Railroad in the economic development of Siberia. Originally, it merely connected major waterway terminals on the Siberian rivers. Alt[illegible]gh a through rail line was eventually developed at considerable cost, this combined water-railroad system across Siberia still has an important function.

d. <u>Pre-Soviet Waterway Development.</u>

(1) The importance of navigable rivers in Russian economic development led to augmentation of the waterway system by means of canals to connect the major navigable rivers and thus provide cross-communication between the seas bordering Russia. The pre-Soviet government concentrated on this phase of river resource development, primarily in European Russia.

(2) Although the VOLGA is the most important navigable waterway of European U.S.S.R., its value was limited because its outlet is on an inland sea, the CASPIAN. The Tsarist government built three major canals to provide communication from the VOLGA to the BALTIC Sea, thus with the ATLANTIC. It also built several secondary canals to connect rivers that drain into other seas, particularly the BLACK Sea that also joins the ATLANTIC. These canals (Plate 1) are briefly described below. (See Table 1 for their present status as some have been abandoned and others rebuilt.)

(a) VYSHNEVOLOTSKIY Canal System (No. 1 on Plate 1 and Table 1): 863 km; built in 1703-09; connects the upper VOLGA to the BALTIC via the TVERTSA, MSTA, and VOLKHOV Rivers and Lake LADOGA.

(b) TIKHVINSKIY Canal System (No. 2): 654 km long; built 1802-17; connects the VOLGA with the BALTIC Sea via the MOLOGA and SYAS' Rivers and Lake LADOGA.

(c) MARIINSK Canal System (No. 3): 540 km; built 1811-13; connects the VOLGA with the BALTIC Sea at LENINGRAD via the SHEKSNA River, Lake BELOYE, Lake ONEGA, SVIR' River, Lake LADOGA, and NEVA River.

(d) OGINSKIY Canal (No. 4): built in 1804; connects the BLACK and BALTIC Seas via the DNIEPER, PRIPYAT', and NEMAN Rivers.

(e) DNIEPER-PRIPYAT'-BUG-VISTULA Canal (No. 5): another connection between the BLACK and BALTIC Seas.

(f) BEREZINA Canal (No. 6): built in 1805; connects the BLACK and BALTIC Seas via the DNIEPER, BEREZINA, and WESTERN DVINA Rivers.

(g) ALEXANDER OF WURTTEMBERG Canal System (No. 7): connects the MARIINSK Canal System with the ARCTIC Ocean via the NORTHERN DVINA River.

(h) SEVERNO-YEKATERININSKIY Kanal (No. 9): built in 1822; connects the KAMA and VYCHEGDA Rivers.

(i) KET'-KAS Canal (also known as the OB'-YENISEYSKIY Kanal) (No. 26): built in 1894; connects the OB' and YENISEY Rivers.

3-03 SOVIET WATER RESOURCE DEVELOPMENT POLICY

a. <u>General.</u> The Soviets have emphasized comprehensive exploitation of water resources rather than a single phase such as navigation, which was the case prior to 1917. The hydrologic program is vast and comprehensive and even includes the influencing of the hydrologic cycle of nature. The program is thoroughly integrated in all phases, but can be separated for purposes of discussion into the following major elements: 1) inland navigation; 2) hydroelectric power; and 3) reclamation and flood protection.

b. <u>Navigation.</u>

(1) One goal is to make the whole inland waterway system of European U.S.S.R. suitable for deep-draft navigation, by improving rivers and constructing large reservoirs (that in many cases approach the magnitude of inland seas), and ultimately to provide a unification of the waterway systems of the European and Asiatic regions.

(2) The waterways development policy of the Soviet Union is a very significant element of its international economic and military strategy. The development of the VOLGA River System for deep-draft navigation and its connection to the BLACK Sea by the VOLGA-DON Canal (No. 15 on Plate 1) provide a means of access from the interior of European U.S.S.R. to Central Europe up the DANUBE. Thus the major Russian seas -- the WHITE, BALTIC, BLACK, AZOV, and CASPIAN -- are to be interconnected by inland waterways that can carry merchant ships and naval craft of 4.5- to 5.0-m draft and 20,000-ton displacement.

(3) This policy extends beyond the country's borders to incorporate the DANUBE into the Soviet waterway system. After World War II, the Soviet Government revoked the international status of that waterway and restricted free navigation rights below VIENNA to the riparian countries. Soviet interest in the DANUBE extends to the planning and construction of hydraulic structures, such as the proposed Iron Gate dam and other projects in the Satellite countries. When the RHINE-MAIN-DANUBE Canal is completed by West Germany and the proposed DANUBE-ODER-ELBE Canal is completed, Moscow, the major cities of the Soviet European Satellites, and many Western European cities will be interconnected by inland waterways. The significance of these developments, for peacetime commercial transportation and for wartime operations and logistical support, is evident.

c. <u>Hydroelectric Power.</u> The production of hydroelectric power is probably the most important component of Soviet water resource development policy. Prior to 1927, most Russian hydroelectric power installations involved high dams and high-head turbines and were located on mountainous headwaters. They were relatively small and had limited production capabilities.

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This type is still being built in marginal regions, but the present trend is to concentrate on construction of large run-of-river plants, employing low-head turbines and relatively low flow-regulating dams. Many of the hydropower installations on the VOLGA project, for example, are patterned after the German run-of-river plants on the RHINE and DANUBE.

d. Reclamation and Flood Protection. Another major phase of Soviet water-resource development policy is connected with the reclamation of the vast steppes and desert regions for large-scale agriculture, forestation, industrial, and population resettlement purposes. Extensive irrigation and drainage projects are conceived for reclamation of agricultural land, followed by flood protection and then by waterway development. In many instances, these irrigation and drainage canals in large land reclamation projects serve as navigation canals. The reverse is also true: many navigation canals have a secondary role as irrigation canals. Flood control, as such, has received little attention in the Soviet Union, as few settlements have been made in the flood plains of rivers. The large multi-purpose hydraulic centers described in the next paragraph inherently have a limited flood control function.

e. Hydraulic Centers. Comprehensive water resource development is a basic element of Soviet policy. Many hydraulic projects in the Soviet Union are multiple-purpose projects, combining riverflow regulation, navigation, hydropower, and reclamation into hydraulic centers called Gidrouzel (Plates 1 and 3, Table 2). Their planning, location, and construction are fitted into the overall economic plan. Such planning and construction of large hydraulic centers has had high priority under the various 5-Year Plans, without regard for the cost in manpower and human suffering.

f. Technological Foundation. The planning and execution of an effective program for developing the water resources of a vast territory like the U.S.S.R. cannot be accomplished without an adequate reservoir of trained and skilled manpower. The Soviet regime has instilled a high regard for technology in its people and has aggressively fostered the training of scientists and engineers and the expansion and improvement of technical educational and research facilities. Scientific work in hydraulics, hydrology, and other disciplines relating to water resources meets the highest standards of quality and is constantly progressing into new and diversified fields. The volume of basic and applied research on these subjects and the resulting quantity of scientific books, papers, and periodicals published are enormous. Thus, a firm and broad technological foundation now exists for comprehensive water resource development in the U.S.S.R.

3-04 GROWTH OF HYDROLOGIC PLANNING

a. With their rise to power in 1917, the Soviets were afforded the opportunity of putting their theories into practice; among them was the development of water resources, a key element in Soviet doctrine. (Earlier, when he was in exile, Lenin was greatly impressed by the advanced technology of Germany and was strongly influenced to ascribe great importance to the development of hydroelectric power.) The period 1917-28 was primarily one of basic planning and organizing in preparation for future large-scale projects. However, some construction was started to provide the nucleus for the future gigantic schemes. In 1921, the first economic plan, known as GOELRO, was introduced, which involved the construction of a series of electric powerplants of limited capacity. These were built with the help of foreign engineers and imported material. Among the larger hydraulic works of this period were the VOLKHOV hydropower development and the SVIR'STROY hydropower cascade on the SVIR' River (No. 3, Plate 1) near LENINGRAD between Lake LADOGA and Lake ONEGA.

b. From 1928-39 considerable progress was made in the development of water resource policies. These years before World War II were dedicated primarily to experimentation in technical education and training and to the overall study of the hydrologic and economic characteristics of the water resources.

c. After World War II the scope of hydrologic planning was expanded to include the Central Asiatic and Siberian regions. The general survey of these water resources made by Professor Davydov in 1945-48 revealed that water was lacking for the proposed extensive reclamation and irrigation projects. This study led to the formulation of a hydrologic policy based on the overall management of water resources, known as the "Great Stalin Plan for the Transformation of Nature." In 1948, this plan was incorporated into official economic policy by decree. It provides for essential changes in the regime of rivers by means of radical physical changes in the land surface and drainage pattern, transfer of streamflow between watersheds, crop rotation, and reforestation of arid areas. By 1955, the follow large hydraulic projects (Plate 1) were either in operation or nearing completion:

(1) BALTIC-WHITE Sea (Stalin) Canal (No. 11 on Plate 1)

(2) Great DNIEPER Development:

- (a) ZAPOROZH'YE Hydropower Center (No. 15)
- (b) KAKHOVKA Hydropower Center (No. 16)
- (c) South UKRAINE Canal and Irrigation System (No. 17)
- (d) North CRIMEA Canal and Irrigation System (No. 18)

(3) Great Volga Development

(4) OB'-IRTYSH Hydropower Development

- (a) UST'-KAMENOGORSK Power Development (No. 19)
- (b) BUKHTARMA Power Development (No. 20)

d. After 1956, the entire planning structure for water resource development was reorganized; managerial control was transferred from the central government to regional authorities and local governments of the individual Soviet republics. Serious deficiencies developed in the water supply needed to carry out the ambitious schemes of the Sixth 5-Year Plan (1956-60), especially for the agricultural reclamation projects. In the current 7-Year Plan (1959-65) complete reappraisal and reorganization of the hydrologic planning and construction program have been made, and several large proposed projects have been abandoned. Although there is speculation in the West that large-scale planning in the U.S.S.R. has thus been abandoned, close study reveals that the hydraulic construction program remains basically unchanged, but with different priorities and a decentralized organization. Unlike the earlier 5-Year Plans, the current 7-Year Plan merely lists the hydraulic projects to be accomplished and their target dates, leaving the details to regional authorities in accordance with current decentralization policies. Major emphasis continues to be placed on the development of Asiatic U.S.S.R.

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SECTION IV

THE GREAT VOLGA DEVELOPMENT

4-01 GENERAL

The VOLGA is important as a key factor in the economy of the European U.S.S.R. and, therefore, the Great Volga Development is an important phase of the Soviets' overall economic planning. The VOLGA has always played an important role in the history of the country because of its strategic location and vast transportation capacity. Even when frozen in winter, it provides an ideal sledgeway to carry a great volume of traffic. Although only the fifth largest river in the U.S.S.R., the VOLGA is the largest river in Europe. It is 3,688 km long and drains an area of 1,480,000 km^2. With its more than 1,000 tributaries, it forms a navigable waterway system more than 20,000 km long. The VOLGA flows southward through the heart of European U.S.S.R to the CASPIAN. In the last 800 km, the riverbed is below sea level; STALINGRAD, one terminal of the VOLGA-DON Canal, is -13.5 m, MSL. The VOLGA enters the CASPIAN through 80 major branches in a delta 170 km wide with an area of 134,000 km^2. The character of the riverbed is an outstanding example of the influence of terrestrial rotation upon river formation, being marked by high right banks and low, receding left banks, which are marshy and subject to flooding.

4-02 MAJOR FEATURES

a. General.

(1) In 1926 because of the serious inadequacy of the Soviet railroad system, a comprehensive study was made of the entire inland transportation system, including an evaluation of the VOLGA waterway system as a transportation carrier. It was estimated that the transportation capacity of the VOLGA at that time was equivalent to that of a 6-track railroad, but that by proper development it could be raised to that of a 40-track railroad. It was decided to maintain the VOLGA as the hub of the transportation system west of the URALS and to make it navigable for seagoing vessels, thus opening up the interior of the area for access to the major Russian seas. MOSCOW was to become the great seaport in the U.S.S.R. The Great Volga Development was also to provide irrigation in the southern region of the U.S.S.R.

(2) The hydrologic aspects of the program were entrusted to Professor Riesenkampf, whose comprehensive plan of development was adopted and has served as the basis for the subsequent development of the VOLGA Basin (see Plates 1, 4, and 5). His plan involved the construction of eight multiple-purpose hydraulic centers, Gidrouzel (see Plate 1 and Table 2), to raise water levels and retain excess spring flood flow behind huge dams. (A typical Gidrouzel is illustrated in Plate 3.)

b. Locks and Dams.

(1) The dams planned by Riesenkampf were huge earth-fill structures, some as long as 13 km but relatively low because of the very low gradient of the VOLGA, which averages only 0.04 m/km (Plate 5). The reservoirs created by the dams approach the size of huge lakes. For example, that at KUYBYSHEV covers 9,500 km^2, extends 600 km upstream from the dam, and holds 38 km^3 of water.

(2) Since the maximum draft of 4.5 m was established for standard commercial vessels, the ultimate project minimum depth was to be 5.0 m. The minimum dimensions of navigation facilities were based on the 200-m by 30-m dimensions of VOLGA River boats. Lock chambers provided at dams on the VOLGA were to be 300 m long (290 m clear length), 30 m wide, with a 5.0-m minimum clearance over the upper sill, which has segment gates hinged at the

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bottom. The downstream miter gates reach considerable height in some cases because of the high lift conditions. Locks of the same type are used on the MOSCOW-VOLGA Canal (see Plate 6). Actual construction, however, has departed from Riesenkampf's original plan, especially in the case of the VOLGA-DON Canal whose locks are smaller, (see Plate 7); this has restricted the usefulness of the system.

c. Navigation Canals. The major purpose of the Great Volga Development, to establish a connection between major Russian seas and make MOSCOW a great seaport of the Soviet Union, was essentially achieved by 1952 through reconstruction of existing canals and construction of new canals. Among the new canals (Plates 1 and 5) are the following:

(1) The Baltic-White Sea (Stalin) Canal (No. 11 on Plate 1) is a 227-km waterway between POVENETS on Lake ONEGA and BELOMORSK on the WHITE Sea. It has 19 locks, overcoming an elevation difference of 75 m, and is navigable for 165 days a year. It was constructed during 1931-1932 in the record time of 20 months and 10 days, entirely by forced labor.

(2) The Murmansk Canal (No. 12) crossing the KOLA Peninsula was a project proposed in connection with the development of the BALTIC-WHITE Sea (Stalin) Canal.

(3) Moscow-Volga Canal (No. 10) is a 128-km artificial waterway between the VOLGA River, at IVAN'KOVO, and the MOSCOW River. The canal is 5.5 m deep and overcomes a 47-m elevation difference by means of 11 locks. It was completed in 1941.

(4) Volga-Don Canal (No. 15) is 101 km long, has 13 locks, and was completed in 1952.

(5) The Mariinsk Canal System (No. 3) is being extensively reconstructed to permit passage of boats of 4.5- to 5.0-m draft, using the previously developed SVIR' River.

d. Hydroelectric Power. The VOLGA River cascade of hydropower structures, together with the development of the tributary river, the KAMA, created the largest hydroelectric power complex in the U.S.S.R., with an installed capacity of 10-million kw and an annual output of 10-billion kw-hr. The KUYBYSHEV and STALINGRAD powerplants are the two largest in the U.S.S.R. Under the new 7-Year Plan, the capacity of the complex is to be increased by one million kw by 1965. The VOLGA and KAMA installations existing, under construction, and planned in 1956 are itemized on Table 2.

e. Irrigation. In accordance with the Soviet policy for multiple-purpose river development, the Great Volga Development included provision for irrigation in the southern regions of the U.S.S.R. The hydraulic centers of KUYBYSHEV, STALINGRAD, and TSIMLYANSK (No. 6, 8, and 14 on Plate 1 and Table 2) were designed with a view of storing water for irrigation of large regions.

4-03 HYDROLOGIC ANALYSIS

a. Conditions Prior to the Development.

The success or failure of such a comprehensive river development project as that of the VOLGA hinges largely upon the supply of water that will be available (see Plate 2). In his investigations in 1927, Riesenkampf estimated the average annual volume of flow of the VOLGA as 255 to 260 km^3. Of this, 65% was carried during the 3-month spring snowmelt period when floods occur. The remaining 9 months was the period of low and medium flow during which the depth of the river was often insufficient for navigation even by shallow-draft boats. The considerable variation in the mean annual flow and in the spring flood volume is shown in the following tabulation of data used in the design of the KUYBYSHEV Dam:

	Annual Volume of Flow (km^3)	Spring Flood Volume (km^3)
Maximum	363	240
Mean	250	153
Minimum	141	86

b. Proposed Changes.

(1) Recently changes in the original design of the Great Volga Development have been proposed. In the beginning Riesenkampf had calculated that an additional 44 km^3 would be diverted to the VOLGA from other basins to meet the water requirements of the project, as shown below. By the end of 1955, however, the planned transfer of 30 km^3 from the DON had been abandoned because of changes in the design of the VOLGA-DON Canal. Furthermore since 1930 the annual flow of the VOLGA itself has decreased sharply and has averaged only 210 to 220 km^3.

(2) A proposed change in the plan is the diversion of 41 km^3 annually from the PECHORA through the KAMA into the VOLGA. The tabulation below shows that the water supply thus available would be 35 to 40 km^3 less that Riesenkampf's original estimate:

Estimated Annual Volume of Flow, km^3

	Original Plan	Proposed Change
VOLGA River	255 to 260	210 to 220
Diversion from:		
ONEGA River	8	8
VYCHEGDA River	6	...
DON River	30	...
PECHORA River	...	41
Total	299 to 304	259 to 269

c. Present Conditions

One important result of the decline of the VOLGA River flow volume has been the continual sinking of the level of the CASPIAN Sea into which the VOLGA discharges. Intensive studies made by the leading Soviet scientists indicate that the Great Volga Development has not only failed to improve the hydrologic balance of the CASPIAN Sea but has also accelerated its sinking; many authorities maintain that the facilities installed on the VOLGA consume at least as much water as they introduce from new sources.

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SECTION V

DAVYDOV PLAN

5-01 GENERAL

a. Significance. The Davydov Plan is a plan for the comprehensive development of the Arctic rivers and the diversion of surplus water to Soviet Central Asia and the CASPIAN Sea. According to Soviet scientific literature dealing with the problem of the sinking of the CASPIAN, the basic idea of the Davydov Plan is very much alive. Soviet oceanographers, such as Apollov, Gyul, Shlyamin, and others, see in the execution of the plan the only solution for the CASPIAN problem and, in general, for the water shortage problem in Soviet Central Asia. Because of the importance of the problem in future Soviet planning and the wide international interest in the proposed construction, which could affect the hydrometeorological balance of the whole Eurasian land mass, the outline of the Davydov Plan is presented here.

b. Utilization of Arctic Rivers. According to Professor Davydov, retention of the present CASPIAN Sea level is absolutely essential for balanced climatic conditions of the southern U.S.S.R. and for the water supply of Soviet Central Asia and Western Siberia. His plan for the exploitation of Soviet water resources was preceded by a hydrologic survey of the country, showing that previous Soviet water resource development plans had not thoroughly evaluated the water needs for rehabilitating vast areas of the Soviet Union, particularly in Central Asia, and had not given proper consideration to the hydrometeorological changes that had taken place. When published in 1948, the Davydov Plan was considered fantastic, impossible to execute. Because of the extreme water shortage, however, one feature of the plan, the TURKMEN Canal (No. 22 on Plate 1) was made part of the Fourth and Fifth 5-Year Plans. This construction was started but later abandoned. Continuation of this construction was not made part of the Sixth 5-Year Plan and the current 7-Year Plan.

5-02 MAJOR FEATURES

a. General.

(1) A major objective of the plan is the irrigation of the deserts and steppes of the relatively sparsely populated area comprising the KAZAKH, UZBEK, TURKMEN, KIRGIZ, and TADZHIK S.S.R.'s. This area is strategically situated to accommodate industry and it also has abundant resources of oil, gas, and metals. Its geographic location, between 35° and 50° N., provides favorable climatic conditions for agriculture; the mean temperature averages between -10° and +4° C. (14° and 39° F.), in January, and between 24° and 34° C. (75° and 95° F.), in July. Intensive cultivation of cotton, rice, and rubber, and other products having industrial uses would be possible if substantial irrigation were provided. The main obstacle to the full realization of the economic potential of this area is its lack of an adequate water supply.

(2) The two principal rivers, the AMU DARYA and SYR DARYA, together carry 56 km^3 annually, nearly all of which the plan has allocated for irrigation of 80,000 km^2. It is estimated, however, that such a diversion would eventually result in a progressive reduction of the surface area of the ARAL Sea from its present 64,500 km^2 to only 12,500 km^2.

b. Hydrology.

(1) For the rehabilitation of the TURAN Depression, including irrigation of 250,000 km^2, the plan would require a minimum of 180 km^3 annually. In addition, Davydov estimated that 56 km^3 annually would be needed to replenish the flow of the AMU DARYA and SYR DARYA and thus prevent

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the sinking of the ARAL Sea. Since the plan provides for a total net annual diversion to this area of 315 km^3, the remainder, 79 km^3, could be utilized for raising the level of the CASPIAN Sea.

(2) The hydrologic balance of the plan as calculated by Davydov is as follows:

Source		Annual Diversion of Flow (km^3)	(m^3/sec)
OB' River		315	10,000
YENISEY River		296	9,400
	TOTAL	611	19,400
Utilization			
BELOGOR'YE Power Development (No. 30, Plate 1)		268	8,500
Transfer to ARAL and CASPIAN Sea		315	10,000
Evaporation and infiltration losses		28	900
	TOTAL	611	19,400

c. Major Structures. The major structures (Plates 1, 8A, and 8B) by which Professor Davydov proposed to divert the flow of Siberian rivers, are as follows:

(1) Yenisey River Dam (No. 28 on Plate 1): to be built below the junction with the PODKAMENNAYA TUNGUSKA River to raise the river level from 30 to 140 m above sea level.

(2) The Ket'-Kas Canal (OB'-YENISEYSKIY Kanal) (No. 26): to be reconstructed as a main waterway to carry 296 km^3 annually (9,400 m^3/sec) westward from the YENISEY River and its tributaries, such as the ANGARA which originates in Lake BAIKAL. This canal was to be approximately 500 km long and drop 35 m through 4 locks to the level of the artificial sea to be created on the OB' River by the BELOGOR'YE Dam.

(3) BELOGOR'YE Dam (No. 30): the key structure of the entire project, to be located on th[illegible]' River below the junction with the IRTYSH River, at BELOGOR'YE. It was to be a gravity dam 100-km long whose crest was to average 78 meters above the present stage of the OB' River. The dam was to create an artificial sea with an impounded water area of 250,000 km^2 and volume of 4,500 km^3 (see Plate 1). The southwest tip of this sea would extend up the TOBOL River to UBAGAN Lake, where the TURGAY River forms a natural gateway to the TURAN Area. The whole area is at present practically uninhabited and consists mostly of marshes, moors, and swampy forests. The project would require the rerouting of only one main transportation artery, the SVERDLOVSK-TYUMEN'-OMSK section of the Trans-Siberian Railroad. Numerous industrial centers are already located or are planned on or near the shores of this proposed inland sea in the heart of Siberia.

(4) Turgay Canal (No. 25): to be cut through the elevated terrain between the Siberian Plains and the TURAN Depression for a distance of 900 km. This new canal, 45 to 75 m deep, would transfer water from the proposed "Siberian Sea" towards the south. The major part of its flow would be distributed through irrigation canals throughout the entire arid land of West TURAN, while the remainder would reach the ARAL Sea.

(5) Turkmen Canal (No. 22): to carry surplus water from the ARAL Sea to the CASPIAN. It was to be a canal 500-km long following the dry bed of the UZBOY River, which once connected the two seas. The construction of this project was abandoned in 1952.

5-03 POTENTIAL BENEFITS

a. General. The most important potential benefit of the Davydov Plan, if completed, is the diversion of Arctic water into the CASPIAN Sea to solve the problem of its sinking.

b. Navigation. The Davydov Plan would create a YENISEY-OB'-CASPIAN Sea navigation system that, like parts of the VOLGA system, would be capable of carrying seagoing vessels. The distance between the OB' at BELOGOR'YE and the CASPIAN Sea is 4,000 km; 1,800 km of this length would be seas, lakes, and reservoirs, 1,000 km would follow ancient river beds (such as the UZBOY, the route of the TURKMEN Canal), and 1,200 km would be newly constructed navigation canals.

c. Hydropower. The Davydov Plan calls for exploitation in seven stages of the hydropower potential of 12.6 million kw total capacity and 83 billion kw-hr annual production.

d. Irrigation. The plan provides for extensive pumping installations by means of which agricultural land up to 200 m above sea level could be irrigated. It is estimated that the water thus available for irrigation would not only sustain 250,000 km^2 of agricultural land, but also permit reforestation of approximately 200,000 km^2 of deserts.

e. Others. This great increase in cultivated and forested areas will have some influence on the climate. Forests in the TURAN deserts would help to protect the depressed areas of Soviet Central Asia against aridity. Some increase in precipitation may result, thus adding to the water supply of the ARAL-CASPIAN Depression and exercising considerable influence on the rivers and streams of the area.

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SECTION VI

CURRENT PROGRAM

6-01 MAJOR OBJECTIVES

The current 7-Year Plan emphasizes the development of Asiatic U.S.S.R. rather than of European U.S.S.R. This industrial and economic development, which began before World War II, is based mainly on the accessibility of raw materials: coal, iron, graphite, copper, silver, lead, molybdenum, wolfram, uranium, and thorium. The problem of meeting the enormous power requirement for industrial exploitation of the region is considerably simplified because of Lake BAIKAL (with its huge water storage) and the giant Siberian rivers. The development of the water resources is an essential feature of this overall plan.

6-02 OB'-IRTYSH DEVELOPMENT

a. The IRTYSH River, already an important inland waterway, is to be developed by the construction of the following multiple-purpose hydraulic centers on its upper reaches:

(1) UST'-KAMENOGORSK (No. 19 on Plate 1), completed in 1953. Its navigation lock provides a 40-m lift, which is the highest in the U.S.S.R.

(2) BUKHTARMA (No. 20), under construction.

(3) PAVLODAR (No. 21), proposed.

b. On the OB' River a multiple-purpose dam has been constructed at NOVOSIBIRSK (No. 22). The reservoir covers an area of 1,071 km^2, and stores 8.8 km^3 of water at 19.6-m head. The total length of the dam, including spillway and powerplant, is 4,830 m. The construction of other hydraulic centers along the OB', including one at KAMEN'-NA-OBI, has been planned.

6-03 YENISEY-ANGARA DEVELOPMENT

a. This project is now being expedited with great vigor because of the huge hydropower potentialities of the ANGARA River.

b. The ANGARA River, affluent of the YENISEY and effluent of Lake BAIKAL, carries an average flow of 1,744 m^3/sec, and drops 360 m during its total course of 1,853 km. Thus, it has an unusually high gradient (0.2 m/km) and a very high velocity, and offers potential energy of 60 million kw. Just below Lake BAIKAL, the sudden drop of 30 m made it possible to construct a dam, whose backwater will raise Lake BAIKAL 1.0 to 1.5 m above its natural level. This will provide an additional water storage of 34 km^3 that may be utilized for hydropower by the ANGARA cascade. This power potential will be exploited by a series of six hydropower plants, as illustrated on Plate 8B. These plants will have a combined installed capacity of 10,065,000 kw, which is on a level with the Great VOLGA cascade. The largest will be BRATSK, with an installed capacity of 3,200,000 kw, which is higher than either the KUYBYSHEV or STALINGRAD powerplants on the VOLGA, now the two largest in the U.S.S.R. The status of the ANGARA development is not entirely clear, although it is known that the plant at IRKUTSK has been completed and the one at BRATSK is still under construction.

c. At KRASNOYARSK on the YENISEY River, a huge hydraulic center (No. 23) has been planned; it is to have a dam 118 m high and a storage reservoir of 2,130 km^2 surface area and 77 km^3 storage capacity, of which 32 km^3 is to be reserved for power production. The planned development is to have an installed capacity of 4,000,000 kw, at 86-m head. the KRASNOYARSK hydraulic center will be designed for combined operation with the ANGARA development. The best

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navigation facilities to overcome this high lift have not yet been selected, but one plan calls for a ship elevator as being the most economical solution.

6-04 CURRENT STUDIES

With the attention of the Soviets turned eastward toward the rich water resources of the giant Siberian rivers, at the same time extensive studies and scientific research are in progress to determine the future course of hydrologic planning. Voluminous scientific literature in various geophysical disciplines (oceanography, hydrometeorology, heliogeography, and the most recent, "helio-hydrometeorology," concerning long-term weather prognosis) indicates that a major aim of future large hydrologic projects in the U.S.S.R. will be to correct the failure of the Great Volga Development to arrest the sinking of the CASPIAN. This problem of the continuous sinking of the CASPIAN is one of the main subjects of research of leading Soviet scientists, as indicated by controversial discussions appearing in publications of the Soviet Academy of Sciences. The ultimate objective of Soviet hydrologic planning continues to be comprehensive development of water resources to fully exploit the vast hydropower potential, to provide a unified waterway system across the Soviet Union, and to reclaim the Central Asiatic regions where the natural "Granary" of the U.S.S.R. is located. For this the Davydov Plan appears to offer the only complete solution. The present water resource development of the Siberian regions continues to conform with the general concepts of the Davydov Plan, although differing in some details. Future development may shift in emphasis depending upon the progress of the 7-Year Plan and upon the overall economic and strategic policies of the Soviets.

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TABLE 1

NAVIGATION CANALS

Serial No. *	CANAL	STATUS
1.	VYSHNEVOLOTSKIY System	in operation prior to 1917; no longer in use
2.	TIKHVINSKIY System	in operation prior to 1917; no longer in use
3.	MARIINSK System	in operation prior to 1917; being completely rebuilt
4.	OGINSKIY	in operation prior to 1917; no longer in use
5.	DNIEPER-PRIPYAT'-BUG-VISTULA	in operation prior to 1917; entirely realined and rebuilt by 1950
6.	BEREZINA	in operation prior to 1917; probably no longer in use
7.	SEVERO-DVINSKIY (formerly ALEXANDER OF WURTTEMBERG)	in operation prior to 1917; still in use
8.	AUGUSTOVO	in operation prior to 1917; probably no longer in use
9.	SEVERNO-YEKATERININSKIY	in operation prior to 1917; no longer in use
10.	MOSCOW-VOLGA	in operation
11.	BALTIC-WHITE Sea (STALIN)	in operation
12.	MURMANSK	proposed
13.	DNIEPER-DON	proposed
14.	DNIEPER-OKA	proposed
15.	VOLGA-DON	in operation
16.	STALINGRAD**	under construction until 1954
17.	SOUTH UKRAINE**	under construction
18.	NORTH CRIMEA**	under construction
19.	DNIEPER-YUZHNYY BUG**	proposed
20.	DNIESTER-ODESSA	proposed
21.	MANYCH	proposed
22.	TURKMEN	under construction until 1952
23.	KARA-KUM	under construction
24.	SOUTH SIBERIAN	proposed
25.	TURGAY	proposed
26.	KET'-KAS	in operation prior to 1917; no longer in use
27.	SIBERIAN Sea Development	proposed
28.	BAIKAL-AMUR	proposed

* Marked on Plate 1 by [1]

** To be used primarily as irrigation canal

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TABLE 2

HYDRAULIC CENTERS (GIDROUZEL)

RIVER BASIN	SERIAL NO. *	NAME	STATUS
VOLGA	1.	IVANKOVO	in operation
	2.	UGLICH	in operation
	3.	SHCHERBAKOV	in operation
	4.	GOR'KIY	in operation
	5.	CHEBOKSARY	planned
	6.	KUYBYSHEV	in operation
	7.	SARATOV (BALAKOVO)	under construction
	8.	STALINGRAD	under construction
	9.	NIZHNE VOLZHSKAYA	proposed
KAMA	10.	NIZHNE KAMSKAYA	planned
	11.	VOTKINSK	under construction
	12.	MOLOTOV (PERM')	in operation
	13.	SOLIKAMSK	proposed
DON	14.	TSIMLYANSK	completed
DNIEPER	15.	ZAPOROZH'YE	completed
	16.	KAKHOVKA	power and navigation phases completed; irrigation phases under construction
INGULETS	17.	INGULETS CASCADE	proposed
DNIESTER	18.	DUBOSSARY	completed
IRTYSH	19.	UST'-KAMENOGORSK	completed
	20.	BUKHTARMA	under construction
	21.	PAVLODAR	proposed
OB'	22.	NOVOSIBIRSK	completed

* Marked on Plate 1 by (1)

RIVER BASIN	SERIAL NO. *	NAME	STATUS
YENISEY	23.	KRASNOYARSK	planned
ANGARA	24.	IRKUTSK	completed
	25.	BRATSK	under construction
	26.	UST'-ILIMSK	proposed
	27.	BOGUCHANY	proposed
YENISEY	28.	PODKAMENNAYA TUNGUSKA	proposed
YENISEY	29.	NIZHNYAYA TUNGUSKA	proposed
OB'	30.	BELOGOR'YE	proposed
TURKMEN CANAL	31.	UZBOY I	proposed
	32.	UZBOY II	proposed
	33.	UZBOY III	proposed

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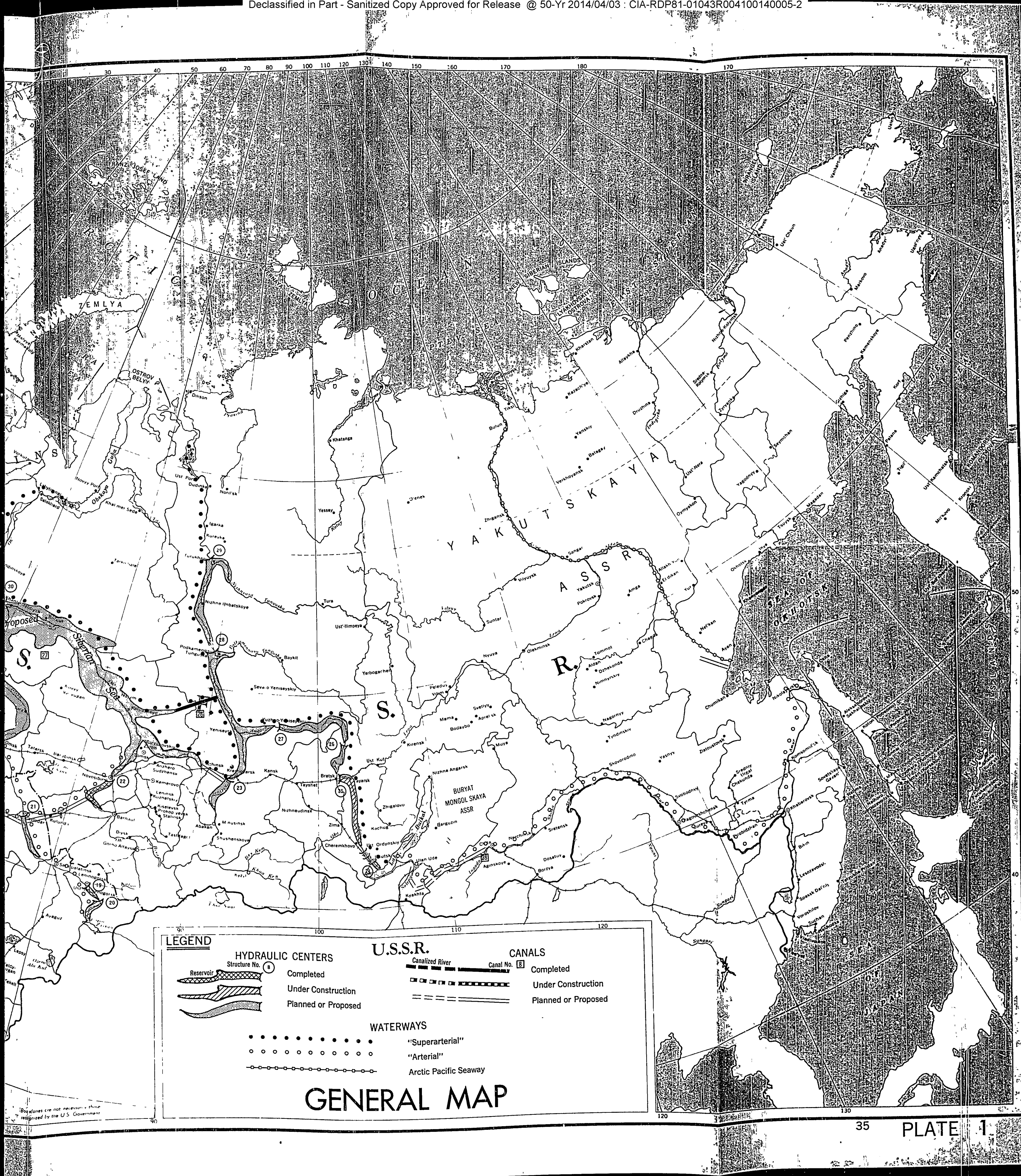

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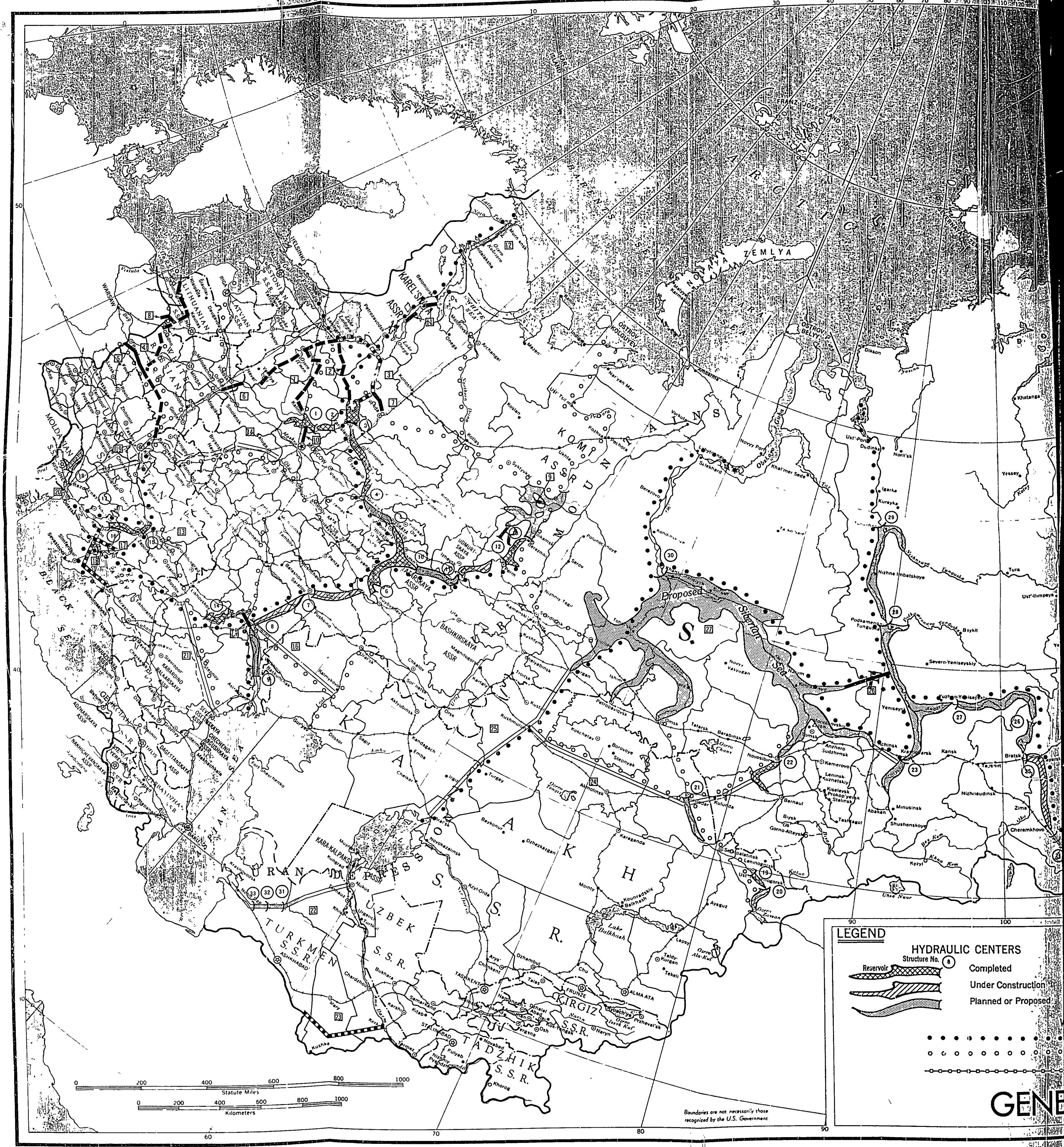

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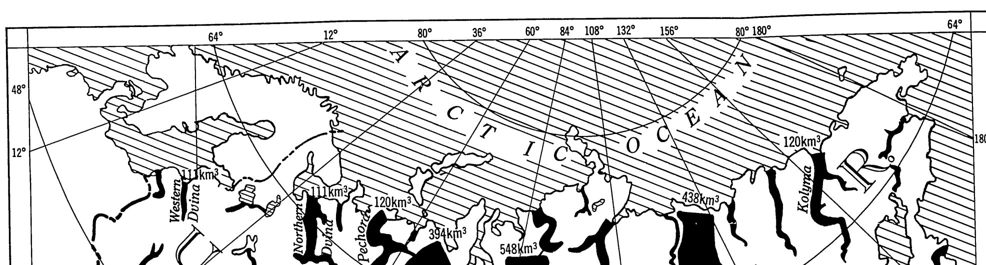

DISCHARGE GRAPH OF MAJOR RUSSIAN RIVERS

NOTE: The width of a river symbol is proportional to average annual discharge.
The average annual volume of discharge is shown in km^3 at mouth of each river.

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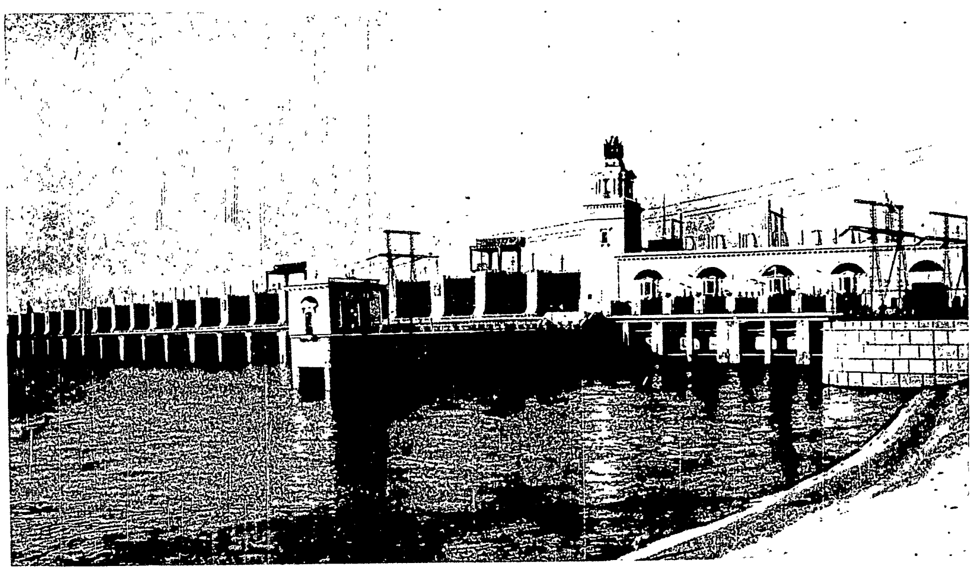

TYPICAL HYDRAULIC CENTER (GIDROUZEL)
TSIMLYANSK ON THE DON
DOWNSTREAM VIEW OF POWER PLANT AND SPILLWAY

PLATE 3

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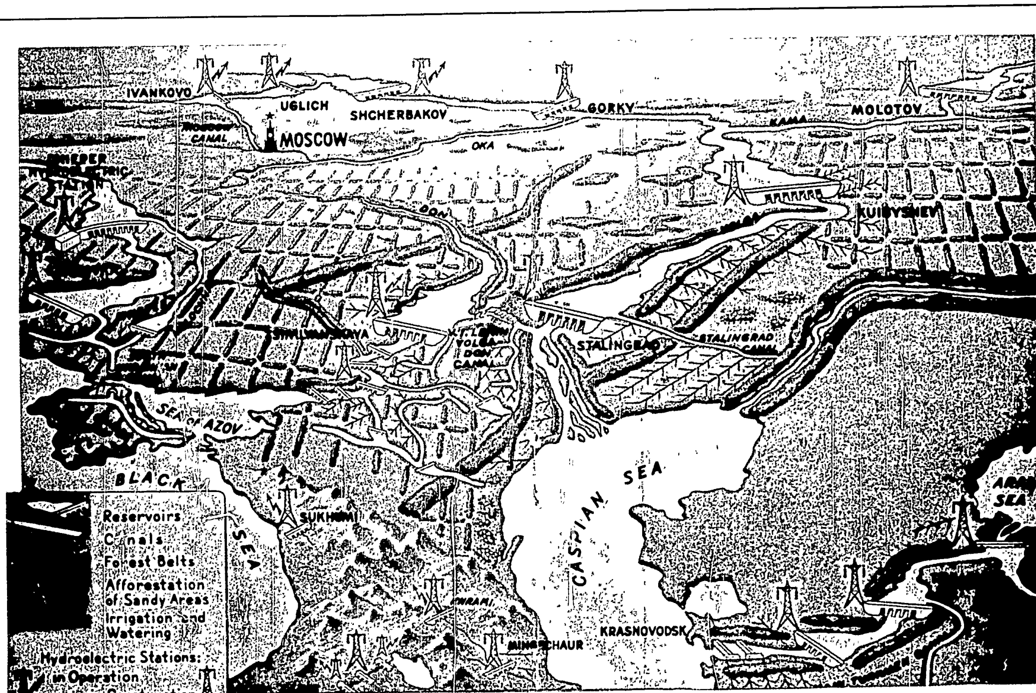

SKETCH OF THE GREAT VOLGA DEVELOPMENT

PLATE 4

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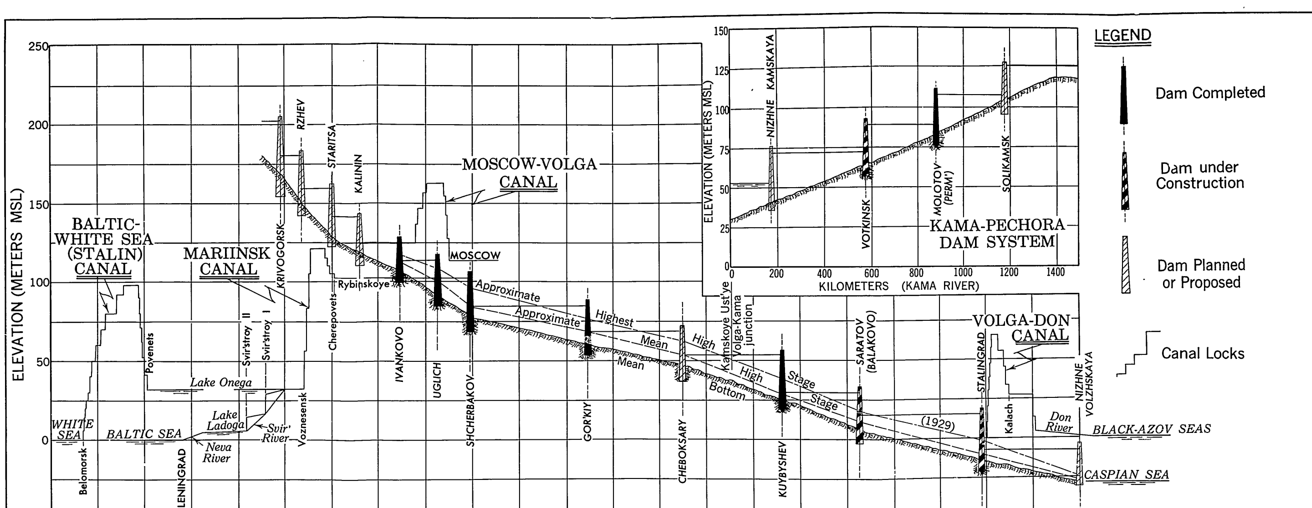

GREAT VOLGA DEVELOPMENT PROFILES

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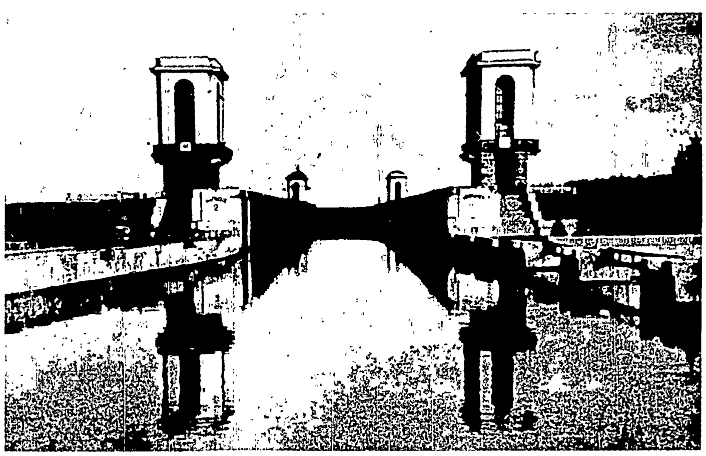

LOCK ON THE MOSCOW-VOLGA CANAL

PLATE 6

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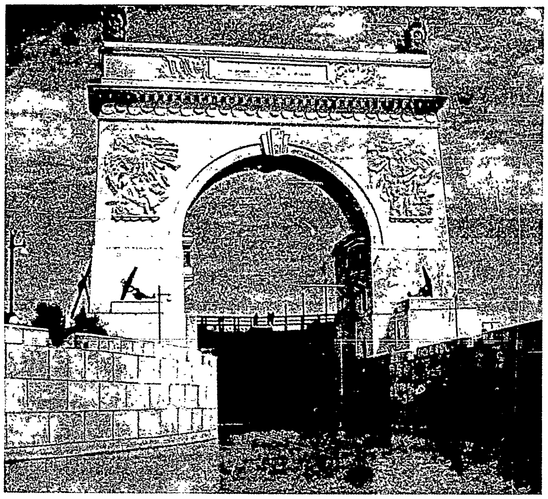

LOCK ON THE VOLGA-DON CANAL

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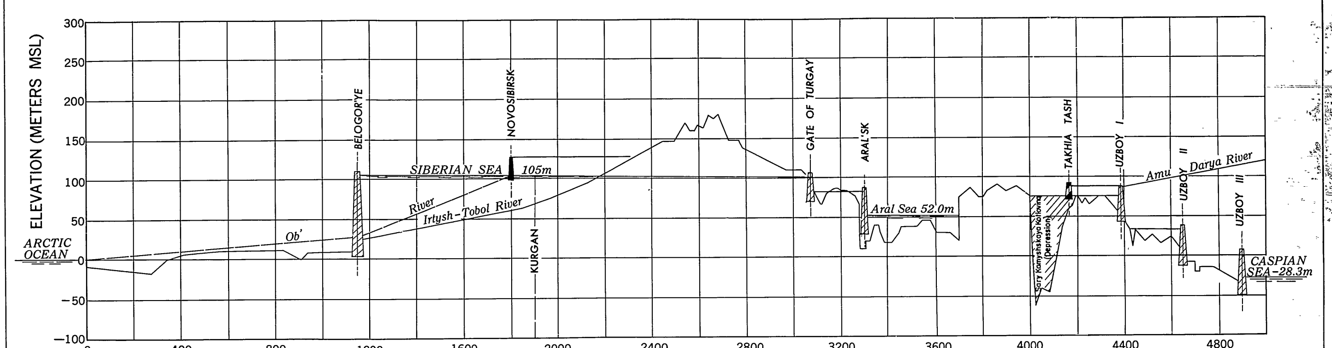

LEGEND

Dam Completed

Dam under Construction

Dam Planned or Proposed

DAVYDOV PLAN PROFILES

OB'-IRTYSH RIVERS, ARAL-CASPIAN SEAS

PLATE 8A

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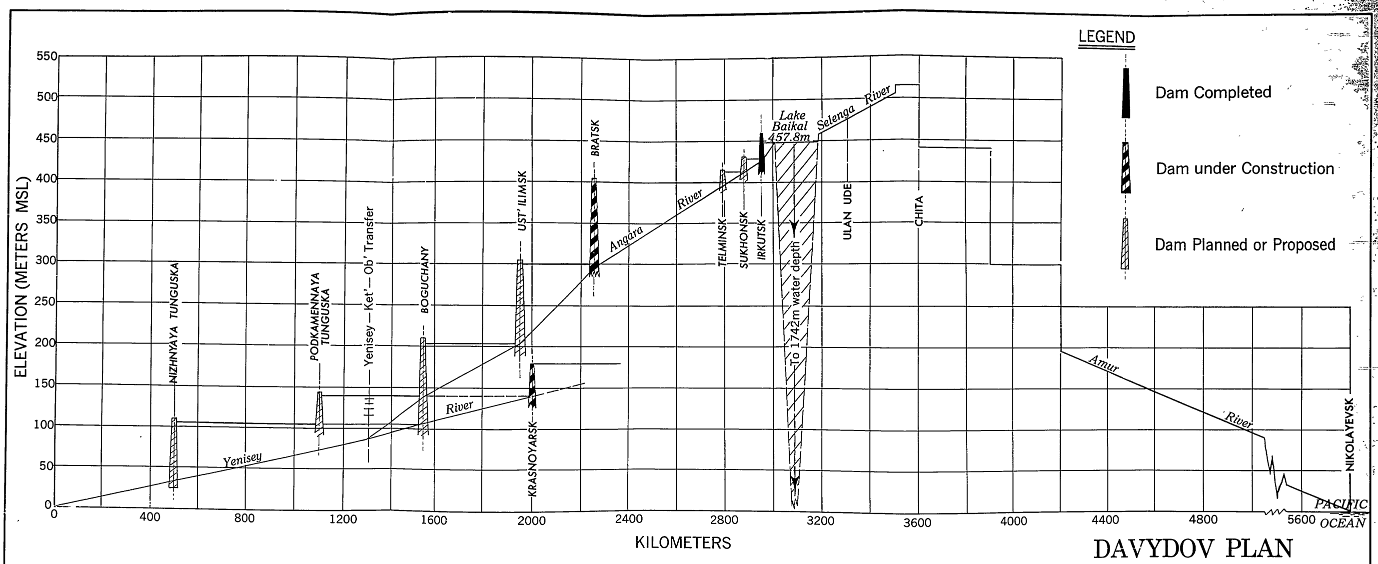

DAVYDOV PLAN PROFILES

YENISEY-ANGARA-AMUR RIVERS, LAKE BAIKAL

PLATE 8B

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