INTERIM REPORT

PHASE ONE

PRELIMINARY RECONNAISSANCE AND CONSULTATION

SUPPLEMENTAL WATER SUPPLY

FOR THE

CITY OF MOSCOW, IDAHO

EBASCO SERVICES
INCORPORATED
ENGINEERS - CONSTRUCTORS - BUSINESS CONSULTANTS
TWO RECTOR STREET
NEW YORK 6, N.Y.
CABLE ADDRESS "EBASCOE"

December 12, 1958

Water Resources Committee
City of Moscow
Moscow, Idaho

Gentlemen:

We submit herewith our Interim Report on Supplemental Water Supply for the City of Moscow. This report covers Phase One - Preliminary Reconnaissance and Consultation specified in our Letter Agreement dated September 2, 1958 which calls for a Memorandum Statement with recommendations for further courses of action to be undertaken in Phase Two of the study.

This Interim Report constitutes the Memorandum Statement. It contains conclusions derived from the reconnaissance trip and review of reports and data made available to us. We have recommended some further exploratory work on the ground-water resources and securing additional maps and data to assist in analyzing the alternative surface water sources. We have also presented our recommendations for Phase Two study which calls for an evaluation of alternative programs involving field exploration of sources of supplementary water supply.

The final report following Phase Two study will present a more complete examination of the water supply problem with formulation of a specific program of supplemental surface water development to meet the growing demands of the City and University of Idaho.

We appreciate the help and cooperation we have received from the members of the Water Resources Committee and others associated with

the City and the University. After you have had an opportunity to review this Interim Report, we will, if you desire, be pleased to make another visit to Moscow to discuss details of our recommended plans.

Very truly yours,

Stasco Services Incorporated

FOREWORD

The Water Resources Committee of the City of Moscow, mindful of their civic responsibility and obligations to the people served by the Water Department, desire to provide a dependable water supply which is adequate to meet the growing demands of the community and provide for industrial expansion. A serious water situation has existed during the last few years because of declining ground-water levels and the necessity for abandoning several developed wells.

The University of Idaho officials have collaborated with the City in their endeavor to analyze the problem and locate new sources of supply which are economically feasible to develop. Several of the Federal Government and State agencies have provided useful information on the water resources of the area and have suggested possible remedies consistent with their functional authority.

The Committee now seeks to obtain an unbiased opinion and has authorized Ebasco Services Incorporated to review the available data and make a preliminary survey in order to present a plan of action for a comprehensive engineering study of the most practicable plan which can be financed and developed by the City. This Interim Report covers Phase One of the over-all study.

The Water Resources Committee is composed of the following citizens:

Spencer Lewis, Mayor of the City of Moscow
Everett Will
George Gagon, University of Idaho
Harvey Smith, City Engineer

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I - SUMMARY

A - PURPOSE AND SCOPE

The letter agreement dated September 2, 1958 between the City of Moscow and Ebasco Services Incorporated calls for a preliminary engineering study of the water situation and analysis of factors affecting future supply of the City and the University of Idaho.

Authorization was received for only Phase One of the engineering and economic study specified in the above agreement and included the following scope of work:

> Review of previous studies which are made available to Ebasco engineers.
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> Review of City and University estimates of future water requirements.
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> Consultations with geologists and others with knowledge of area conditions.
>
> General reconnaissance survey of possible sources of supplementary water supply.
>
> Meeting with City and University representatives to discuss features of alternative water supply sources.
>
> Memorandum statement of reconnaissance results and recommendations for further courses of action to be undertaken in Phase Two of the study.

Phase Two will involve a more detailed investigation in accordance with recommendations presented in this Interim Report, with an economic study and evaluation of alternative programs of development.

A general reconnaissance survey of the present water systems and possible sources of supplementary water supply was made by M. G. Salzman, Ebasco Services Incorporated, who arrived in Moscow on October 7 and remained until October 13. During that period, meetings and discussions took place with the members of the committee selected by the Mayor to work with Ebasco on the water problem. A trip was made with City Engineer Harvey Smith over the watersheds of the South Fork of the Palouse River and Paradise Creek to observe conditions for possible development of surface water reservoirs. Visits were also made to the existing wells which are the present source of water supply for the City and the University of Idaho. Data on output, water levels and operating characteristics of the wells were obtained and various ground-water reports and hydrologic information compiled by Government agencies and staff members of the University were reviewed.

B - CONCLUSIONS - PHASE ONE

1) There is a limited supply of ground water in the Moscowbasin which should be conserved by joint use of supplemental surface water to take care of the future requirements of the City and University of Idaho.

2) Present data are insufficient to determine the safe yield of the artesian aquifers which are now tapped by the City and University wells, but geological indications are that considerable water remains in storage. Water levels have progressively declined, but the decline appears to have moderated during the last two years. (USGS estimate of average annual recharge is about 4,000 acre-ft, which greatly exceeds present annual pumpage of about 2,000 acre-ft.) Additional underground flow may be intercepted by deeper and more widely spaced wells. The extent of the aquifer and the locations and depths of new wells should be determined by test holes and geophysical exploration.

3) Supplemental water supply for future industrial, agricultural and domestic requirements should be obtained by the development of storage reservoirs for the utilization of surface flow. (It is estimated by USGS that average annual runoff from surface streams in the Moscowbasin is about 12,000 acre-ft.) Several possible sites for on-stream and off-stream reservoirs exist on the tributaries and main stream of the South Fork of the Palouse River, with short transportation distance to connect with the City and University water systems. These can be developed, as required, to supplement the supply from the wells and to moderate the decline of ground-water levels. Some increased recharge to the underground flow may result from infliltration of the storage in these reservoirs.

4) It does not presently appear necessary or economic to divert surface water from outside of the Moscow basin in view of the availability of adequate runoff from the South Fork of the Palouse River. However, possibilities exist for future diversion of water from (a), Potlach River, at a point below Juliaetta, about 15 miles airline distance southeast of Moscow, (b), Clearwater River above Lewiston, which would be about 18 miles airline distance from Moscow, or (c), North Fork of the Palouse River, about 12 miles airline distance north of Moscow. Use of any of the above possible sources would entail high pumping costs to overcome friction and static head differential, and long aqueducts to avoid high ridges.

C - RECOMMENDATIONS - PHASE TWO

The following recommendations suggest items which should be considered and further investigated in Phase Two. These are listed in order of preference, and it is not anticipated that work on all recommended items need be started simultaneously. Included are some procedures already under way. Continuing the accumulation of data which will be needed in the long-range program of development is desirable. The expenditures for these items can be controlled by the availability of funds and the necessity of meeting the growing water demand. The assistance and cooperation of the University and Governmental agencies in securing information which is useful and beneficial to all will undoubtedly continue and should result in participation in the cost of the work.

1) The City should continue drilling No. 6 well to base rock and explore the hole by electric log to determine location and extent of water-bearing formations. If log indicates that a satisfactory well can be developed, a pumping test should be made, with careful observations of influence on nearby wells, to determine yield and hydraulic characteristics of aquifer.

2) Participation in geophysical exploration of Moscow-Pullman area by seismic apparatus as proposed by Washington State College should be investigated. If this does not appear

practicable, the feasibility and cost of utilizing the services of an experienced firm with mobile geophysical equipment to obtain information regarding configuration of bedrock and extent of water-bearing formations should be investigated.

3) To further exploit ground-water supply and determine preferable location for new wells, test holes should be drilled by rotary method to bedrock. These will be smaller diameter than if developed for use as a well, and should be drilled at lower cost than present method of cable tool drilling. If satisfactory subsurface material and water yield is indicated, the test hole will serve as a pilot hole and can be reamed for permanent well.

   It is recommended that one test hole be drilled in the bottom of the valley of the South Fork of the Palouse River about 1/2 mile south of the City limits. Another test hole should be drilled about 1 mile northwest of present City pumping wells. Electric logs should also be made in these holes to aid in determination of aquifer location and yield, and quality of water; to be determined from lag and test of drill stem samples.

4) Field investigation and comparative economic study should be made of alternative sources of supplemental surface water supply. This will include determination of reservoir capacity and yield, pipeline route and cost of water delivered to City. The following sites for reservoirs have been tentatively selected during the preliminary reconnaissance, but their locations may be changed and other sites included when more topographic data is available:

   a) Robinson Lake Site - about 5 miles northeast of Moscow center on a tributary of South Fork of the Palouse River below Crumarine Creek. Enlargement of existing Robinson Lake by construction of new dam, a short distance downstream from the existing dam. Study of possible diversion of Gnat Creek for additional water yield.

      An extension of time should be obtained for satisfaction of the permit for the Robinson Lake Site, in order to allow the time necessary to make a detailed engineering study. The permit to appropriate public waters was obtained by the City of Moscow in October 1955 and required start of construction in 1958 with beneficial use of the water within 5 years.

b) Paradise Creek

Comparison of a storage reservoir on-stream about 2-1/2 miles northeast of City center, and on off-stream reservoir near northeast City limits.

c) South Fork of the Palouse River

Comparison of on-stream storage reservoir about 3 miles southwest of Moscow center near Washington-Idaho state line with an off-stream reservoir near south City limits with low diversion dam and pumping plant on the main stream.

5) In order to locate dam sites and evaluate reservoir costs for an incremental development program, additional topography should be obtained of the watershed of the South Fork of the Palouse River. For comprehensive coverage and complete analysis a USGS quadrangle map with 20-ft contour intervals is desirable, and steps should be taken to promote Government mapping of the Moscow basin area through the local U S Geological Survey Water Resources Branch and the State Reclamation Engineer. In lieu of this, an aerial survey company should be engaged to make topographic maps by photogrammetric methods of selected areas for reservoir planning.

6) Systematic water quality analyses and suspended silt load measurements should be obtained on Crumarine Creek, Gnat Creek, Paradise Creek and South Fork of the Palouse River for use in the determination of water treatment and reservoir design. Water samples should be taken monthly and may possibly be correlated and analyzed by University of Idaho Engineering Experiment Station staff in cooperation with USGS Water Resources Branch and U S Soil Conservation Service.

7) With continued City and University growth and water use, there will be increased availability of effluent from the expanded City sewage plant. Systematic water measurement and chemical analysis should be made of this effluent and the pumping plant and pipelines laid out for increased use of water by the University for irrigation and lawn sprinkling.

II - DISCUSSION

A - DESCRIPTION OF WATER SUPPLY SOURCES

The City of Moscow and the University of Idaho obtain all of their present water supply from wells tapping the artesian aquifers in the Moscow basin. This basin occupies an area of about 60 square miles and was formed by erosion of the ancient Columbia River valley which has since been partially filled with sedimentary materials and basalt lava flows. The ground water occurs under water table (unconfined) conditions in the unconsolidated surficial sediments and under artesian conditions in the sands of the Latah formation and the aquifers of the Columbia River basalt. The geological interpretation of the area formation is that a weathered mantle of reworked sand, gravel, silt and clay overlies the crystalline rocks, and at least two groups of Columbia River basalt are interbedded with the sands of the Latah formation. The sand beds and the permeable zones in the basalt are the artesian aquifers which are the source of the water supply for the City and the University.

The Moscow basin is enclosed on three sides by highlands and mountain ranges with outcrops of weathered crystalline base rock appearing in the upper reaches. It is contiguous with the Pullman basin on the west, which has similar hydrogeological characteristics. The region is characterized by broad, rolling topography known as the Palouse Hills and is drained by small streams which rise on the slopes of the mountains to the north and northeast and flow south and westerly to the Snake River.

The City has three wells located at the central pump station in the City, of which two are pumped regularly and one is maintained as stand-by. These wells are presently from 240 to 280 ft deep and water is apparently derived from the lower level of the top basalt layer at about the 250-ft level. The static level of water in the wells has dropped from near ground surface elevation in 1892 to about 90 ft in 1958. The rate of decline has accelerated with increased water use and dropped about 10 ft during the summer of 1955. From 1956 to date the rate of decline of static levels appears to have decreased, but pumping levels have continued to be lower with increased well pumpage.

Another City well is located about 1/4 mile northerly from the central pump station. This well was initially drilled to a 280-ft depth and produced satisfactory yield on test and following installation of pumping unit in 1956. The yield decreased in 1957 and the well is now being drilled to a greater depth (presently 930 ft) in an endeavor to strike a lower aquifer to augment the diminished supply. Two other wells have been drilled, one at the northeast and one at the east City limits, but these were subsequently abandoned when no satisfactory water yield was obtained.

Appendix A contains details on the history and development of the present City wells and general trend of static water levels prepared by the City Engineer's office.

City storage facilities and fire protection reserve are provided by two elevated tanks with combined capacity of 800,000 gallons. There are about 25 miles of water mains to convey water to various parts of the City. No chemical treatment is presently given to the water which is relatively hard and has recently shown an increase in iron content.

The University of Idaho has an independent ground-water supply obtained from two wells on their property in the southwest section of the City. Interconnection with the City water mains at several points provides for mutual fire protection and assistance. The University also has a 500,000-gallon elevated storage tank floating on their system and a small pumping plant located on Paradise Creek for irrigation of adjacent farm property.

In addition to the above, the University has a deep well isolated from their system on the Parker test farm located about 2 miles east of the City limits. This well is pumped intermittently for irrigation and farm use. A private concern, Sunset Memorial Gardens, has a deep well drilled in the artesian aquifer which is used primarily for lawn watering. Several industries and rural stock farms have small wells drawing from the unconfined shallow aquifer.

B - REVIEW OF PREVIOUS STUDIES

The following studies, reports and water data have been made available for review and information during the preliminary investigation:

1) Ground Water in the Pullman Area, Whitman County, Washington
   By B. L. Foxworthy and R. L. Washburn
   USGS Open File Report - October 1957

2) A Water Balance Study of Two Small Watersheds
   By George L. Bloomsburg, University of Idaho
   Thesis Report - September 1958

3) Precipitation Measurements - Period 1956-57
   By University of Idaho - Engineering Experiment Station

4) Report of Field Examination of South Fork of the Palouse River Watershed, Latah County, Idaho - Whitman County, Washington
   By U. S. Soil Conservation Service - January 21, 1957

5) Ground Water Problems in the Vicinity of Moscow, Latah County, Idaho
   By P. R. Stevens
   USGS Unapproved Report - June 1956 - Revised July 1957

The investigation of ground-water resources of the Pullman area in Washington (Report No. 1) was made by the USGS Ground-Water Branch, Seattle District Office, in cooperation with the Washington State Division of Conservation and Development. This included a portion of the adjacent Moscow area in Latah County, Idaho.

This report indicates that there may be a hydrogeologic connection between the Pullman and Moscow areas, but there is probably a ground-water barrier near the State line. The Moscow water table is 158 ft higher than at Pullman; the water levels in the two areas dropped at about equal rates until 1952 when the Moscow area began to drop at a faster rate. There is also a higher content of calcium and magnesium and more hardness in the water from the Moscow area than from Pullman.

It is concluded in the USGS report that the over-all movement of ground water is to the west towards the City of Pullman, which is the center of major pumping; also, that the present rate of pumping may be equal to, or even exceeding the "safe yield" of the artesian aquifer under natural conditions. The report states that "geologic and hydrologic conditions are favorable for the existence of potentially good aquifers below those presently developed." Artificial recharge is suggested by the injection of water from perennial flowing streams into one or more wells penetrating the artesian zones.

Mr. Bloomsburg's thesis (Report No. 2) describes a hydrological water balance study of small watersheds, Crumarine Creek and Gnat Creek, tributaries to South Fork of the Palouse River. It is based on runoff records of three recent years correlated with longer precipitation records at University of Idaho gage at Moscow and at several gages on the respective watersheds.

The report gives average annual precipitation as follows:

Moscow	21.7 in.	(Actual 66-year mean)
Gnat Creek Watershed	29.9 in.	(Calculated)
Crumarine Creek Watershed	37.0 in.	(Calculated)

During the lowest year of record (1911) precipitation at Moscow was 10.9 in. and the minimum would, therefore, be about half the average at the watershed stations. Runoff was determined to be from 22 to 25 per cent of annual precipitation and ground-water recharge estimated from 7 to 35 per cent of annual precipitation with 15 per cent as an average value. This report is valuable as it provides a prediction of probable yield of forested watersheds based on precipitation and runoff records with assumed water losses from evapo-transpiration.

The University of Idaho is conducting a considerable amount of research in cooperation with Federal and County Soil Conservation agencies and the Department of Agriculture-Engineering Experiment Station. It has established several heated orifice-type gages at high altitudes for measuring accumulated precipitation to obtain correlation with water use experiments. The 1957-1958 records (average year condition) indicate an amount of precipitation and runoff from Crumarine and Gnat creeks almost identical to the findings in Mr. Bloomsburg's thesis. The average annual yield from Crumarine Creek was 1,160 acre-ft and Gnat Creek 1,660 acre-ft. Forested land makes up 88 per cent of the Crumarine Creek area and 53.5 per cent of the Gnat Creek area.

The Field Examination Report by the U S Soil Conservation Service (Report No. 4) was in response to the joint application of the Cities of Moscow and Pullman and the surrounding Soil Conservation Districts for technical and other assistance of the Federal Government for a comprehensive watershed development plan for the entire South Fork of the Palouse River. This comprised a general survey for purposes of soil conservation, forestation, water supply and flood control. No definite recommendations

are included in the report, but the drainage area map shows three potential reservoir sites in Idaho; one on Paradise Creek, about 3-1/2 miles north of Moscow; one on Crumarine Creek, about 5 miles northeast of Moscow; and one near the Washington-Idaho state line about 3 miles southwest of Moscow. The economic feasibility of these sites was not revealed and it is understood that no action has been taken on the results of the survey.

At the request of the City of Moscow and the Idaho State Reclamation Engineer, a recent study of the ground-water conditions in the vicinity of Moscow was made during the latter part of 1955. Data were collected and compiled in a preliminary report (Report No. 5) which has not yet been released for publication. This study estimates the amount of probable ground-water recharge and surface water runoff based on record of annual precipitation and assumed runoff and losses from evapo-transpiration and seepage. It is indicated, however, that because of the inadequacy of available data this estimate might be considerably in error. The estimated recharge area is 32.4 square miles or about half of the catchment area. The annual pumpage from all of the wells in the Moscow area in 1955 (when the report was prepared) was estimated to be about 2,200 acre-ft. In view of the declining ground-water level, it was concluded that the supply of ground water was barely adequate for current needs and that there was a continual draft from underground storage.

The USGS report recommended that there should be use of surface water from perennial streams in the area as a source of supplemental water supply for the City and as additional recharge to the artesian aquifers in order to retard further water level decline.

C - FUTURE WATER REQUIREMENTS

An estimate of future water requirements of the City of Moscow and the University of Idaho has been made for this study on the basis of estimated population growth and increased water use for 5-year periods up to 1985. Appendix B is a tabulation prepared by the City Engineer's office showing breakdown of the City and the University population and estimated water requirements for conditions of normal expected growth and possible total annual and maximum use.

The present (1958) City population of 9,360 and University enrollment of 3,916 totals 13,276. The City records of water used from January 1 to October 31, 1958 indicate a total of 303,880,700 gallons, and this was increased to 345,158,900 gallons with estimated November and December consumptions. The average per capita use was, therefore, only 101 gallons per day (gpd) but it was estimated that the use would have been 403,598,000 gallons or 118 gallons per capita per day (gpcd) if increased water rates and voluntary restrictions had not cut the normal use. The University records and estimated balance for the year was 190 million gallons, making a total combined 1958 estimated use of 594 million gallons or 122 gpcd. This rather low per capita use reflects a predominance of residential use with very little industrial consumption and is considerably below the national average municipal water use. It is understood that a large clay processing plant may be established in the Moscow area and several other industries may be developed which would substantially increase future per capita use.

The present City peak demand occurs in summer and is estimated to be 1.54 mgd (1080 gpm). The present rated capacity of the two pumping Wells No. 2 and No. 3 is about 3.5 mgd (2450 gpm). Maximum capacity of all 3 wells at the City pumping plant would be about 4.2 mgd (2950 gpm) but this output could not be sustained because of excessive drawdown and dewatering of the pumps. Well No. 1 is a very old well and not reliable for continuous pumping.

The two wells of the University have a combined rated capacity of 2.14 mgd (1500 gpm), but Well No. 1 is pumped only intermittently because the water level drops below the pump bowls and breaks suction. Iron deposits in the piping system and incrustation of pump bowls in both City and University wells has been a severe problem requiring considerable maintenance. Adequate stand-by capacity in the form of reserve wells for pump outage is necessary.

During the summer of 1958, the peak demand of the University was about 1.12 mgd (785 gpm) and peak day consumption was 893,112 gallons. Much of the University water is for irrigation and farm use including tree genetics and reforestation. A considerable amount of water is used in the various laboratories and for refrigeration. Lawn sprinkling and domestic use was curtailed because of declining water levels and it was stated that unrestricted agricultural activity and new ground development could have considerably increased the summer peak demand.

The forecast of future water requirements and of estimated population growth indicates the following:

	Population	Annual Water Requirements			
		Millions of Gallons			
	Total Combined City and Univ.	Normal	% Increase Over 1958	Possible	% Increase Over 1958
1958	13,276	594			
1960	13,959 11,183	665	11	831	40
1965	32% 16,894 / 4,800	801	35	1000	68
1970	54% 19,257 / 7250	913	54	1141	92
1975	67% 20,950 / 8,670	993	67	1241	109
1980	80% 22,540 10,100	1066	80	1332	124
1985	23,750 2,500	1123	90	1403	137

The above figures indicate normal per capita use of 130 gpd in 1985 and possible increase to 162 gpd. This latter usage is more in keeping with the national trend of expanding per capita use with the advent of more water-consuming household appliances and sanitary improvements. The influx of new industries with large water use and additional University requirements could increase this per capita consumption. On the basis of these figures, however, the water requirements for 1985 may be from 3,500 acre-ft to 4,500 acre-ft per year or approximately double the 1958 combined City and University requirements of 1,850 acre-ft. A possible peak demand of 4.76 mgd (3330 gpm) is indicated for 1960 which would approach the rated capacity of the two operating City wells and one University well. By 1965 the maximum daily requirement may be 5.66 mgd (3960 gpm) which would exceed the combined rated capacity of all of the City and University wells presently in operation. Peak demand in 1985 is 7.45 mgd (5200 gpm) or about double the average daily requirement of 3.85 mgd.

D - CONSULTATIONS WITH GEOLOGISTS AND OTHERS

In view of the availability of several ground-water reports with geological interpretation of the area, it was not considered necessary to consult additional geologists for the preliminary investigation. General geology and climatological data were discussed with staff members of the University of Idaho Department of Agriculture. Water use, irrigation requirements and snow survey data were reviewed with local representatives of the U S Soil Conservation Service.

Some of the geologists and engineers who were associated with the ground- and surface-water investigation are no longer in the area. For the subsequent study and Phase Two report, it will be desirable to obtain all pertinent data and consult USGS Ground-Water Branch office and U S Soil Conservation Service representatives in Boise who may have additional maps or survey material available.

E - RECONNAISSANCE SURVEY OF POSSIBLE SOURCES OF SUPPLEMENTARY WATER SUPPLY

The reconnaissance survey included the upper watershed of the South Fork of the Palouse River. The Palouse River flows into the Snake River in the State of Washington about 60 miles west of Moscow. The principal tributary streams of the South Fork of the Palouse River are Crumarine Creek, which joins the main stream about 4 miles northeast of Moscow, Gnat Creek, which merges with Howard Creek and joins the river about 1 mile downstream from the mouth of Crumarine Creek, and Paradise Creek which flows south and west through the City to eventually join the river near Pullman. The channel of the South Fork of the Palouse River flows westerly about 1 mile south of the City limits.

The flow of the tributary streams is intermittent and during the reconnaissance trip was negligible except for some springs in the upper reaches. There is a wide variation in daily flow of the South Fork of the Palouse River as measured by the USGS gage near Pullman, Washington with extremely low flows occurring during the summer months. Short-term flow records of Paradise Creek at Moscow and South Fork of the Palouse River near Moscow were made by USGS from 1936 to 1939 and are published by the Department of Agriculture. Early in 1956 stream flow gages were established by the University on the upper reach of Crumarine Creek and on Gnat Creek near its mouth for the determination of rainfall-runoff relationship in the water balance studies.

A potential reservoir site on the upper South Fork of the Palouse River watershed below the confluence with Crumarine Creek, known as the Robinson Lake Site, has been previously investigated in a preliminary way by the City. Another reservoir site on Paradise Creek was included in the U S Engineers Columbia River Flood Control Survey. Both of these sites were visited and reviewed in the light of present conditions as possible sources of supplementary water supply.

No USGS Quadrangle or topographic maps of the eastern Moscow basin were available for use during the reconnaissance. Department of Agriculture aerial photographs and Metsker's Map of Latah County were used for general orientation and road locations. The U S Soil Conservation Field Examination report contains a small map which outlines the general drainage area and lists three possible storage reservoir sites in the Moscow area which have been considered in the comprehensive plan for watershed control. The aerial photographs were studied to assist in the location and visualization of the surficial contours and character of the drainage areas.

The following general comments and observations were made of potential reservoir sites for storage of surface water:

1) Robinson Lake Site

An excellent dam site is available about 1/4 mile below existing Robinson Lake dam. It is located below the confluence of Crumarine Creek and an eastern arm of the South Fork of the Palouse River. The hills converge at this point to form a narrow valley. The walls on both sides reveal outcrops suitable for the abutments of a thin arch or an earthfill dam. The existing Robinson Lake is owned by Latah County. The new dam would raise the level of the existing lake and provide increased storage for flood waters. It may be possible to acquire the site for water supply use if limited recreation privileges were permitted.

A preliminary topographic map of the reservoir area was made by the City from which the storage-area curve indicates that a dam with height of 80 ft would impound about 2,700 acre-ft (900 mg) and create a reservoir with surface area of about 100 acres. The economic height of dam, storage capacity and drawdown is a matter for more detailed engineering analysis.

The U S Soil Conservation Service Field Examination Report includes this site as Reservoir No. 2 and indicates a drainage area of 8.19 square miles (5,250 acres) with minimum yield of 3,230 acre-ft based on 24.4-in. precipitation and average yield of 6,120 acre-ft with 31.3-in. precipitation.

Most of the watershed area consists of forest and timber, but there is some upstream land under cultivation. Sedimentation of the reservoir from land erosion and bank scour must be carefully studied. Robinson Lake has already experienced heavy silt deposit and has been partially cleaned out by the County. Drop structures and small barrier dams, strategically located across tributary channels and improved measures of land treatment may be employed to reduce the amount of silt which will be carried into the reservoir. Measurement of the amount of suspended load during heavy runoff periods will enable predetermination of the amount of storage capacity to be allowed for silt deposit and provision should be made for sluicing of silt through gates placed near the base of the dam.

A profile of a possible route for conveyance of stored water to the City distribution system will be required. Gravity flow through the present stream channel to a service reservoir near the City is feasible as there appears to be a drop of about 125 ft between the present Robinson Lake level and a point in the City center. An open channel will, however, be subject to pollution and a close pipeline would be preferable for quality control. Sedimentation will take place in the storage reservoir, but filtration or an additional settling basin to reduce turbidity may be required. Water samples of Robinson Lake and entering streams have recently been taken by City engineers, but no reports are available of their chemical analysis. Additional tests should be made during high flow periods to determine if treatment other than protective disinfection is required.

2) Gnat Creek Diversion

There is a possibility of increasing the yield of the Robinson Lake Site by diversion of runoff from the adjacent Gnat Creek watershed. Mr. Bloomsburg's water balance study reveals that there is less precipitation and runoff on the comparatively narrow and smaller Gnat Creek drainage area of 4.25 square miles

(2,725 acres) than on the Crumarine Creek watershed. He estimates that runoff will be about 820 acre-ft in the year of lowest precipitation and about 1,600 acre-ft during years of normal precipitation.

Topographic data will be required for study of the most practical method of diversion into the pipeline or channel since it appears uneconomical to pump back into the enlarged Robinson Lake. The feasibility of a small storage reservoir on Gnat Creek with separate pipeline or outlet channel to Moscow should also be investigated. It is contemplated that this diversion would be a second-stage development of the Robinson Lake Site but should be included in the over-all engineering study of the project.

3) Paradise Creek Site

The upper portion of the Paradise Creek watershed is similar in character to that of Crumarine Creek and is mainly forest land. A reservoir site designated as Site No. 1 in the Field Examination Report of the U S Soil Conservation Service is located about 3 miles northeast of the Moscow City center where cultivated land would have a higher value than at Robinson Lake and would be more difficult to obtain. The report indicates a drainage area of 7.26 square miles (4,650 acres) and a minimum yield of 1,620 acre-ft with 21.2 inches precipitation and an average yield of 3,870 acre-ft with 27 inches precipitation. The yield per square mile of drainage area is, therefore, considerably less than on the Crumarine Creek watershed. Topographic data is not available, but it appears that the dam would be much longer and the reservoir area larger than for the development at Robinson Lake. With higher land values involved this would probably be much more costly storage. However, the distance for transportation of the stored water to the City would be shorter and the over-all cost of water may be comparable.

Downstream water rights should be investigated and a topographic survey made for further consideration of this project.

4) South Fork of the Palouse River Sites

A trip along the river from the north-south Highway 95 to a point beyond the Idaho-Washington state line revealed a possible reservoir site with a location for the dam a short distance across the line in Washington. Most of the reservoir would be in Idaho and would be farm land under cultivation. Topographic data is not available for present determination of the probable storage capacity or flooded area. This site was also considered and designated as Reservoir No. 5 in the Soil Conservation Service Field Examination Report, but no data on the drainage area and yield is included in the tabulation in this report. A rough determination of drainage area from the watershed outline map is about 30 square miles (19,000 acres), and the yield based on average Moscow precipitation of 21.7 inches and annual runoff of 5.5 inches (25 per cent) would be 8,700 acre-ft. Minimum yield based on 10.9 inches (1911) precipitation at Moscow would be about 4,300 acre-ft.

A reservoir at this location would require pumping about 3 miles over the ridge separating the South Fork of the Palouse River from Paradise Creek. It is probable that the river in this lower reach of the watershed would be more contaminated than at points farther upstream as it passes through many farms and some developed area. The probability also exists that downstream water rights exist and some provision would have to be made for release of compensation flow with only storage of flood flows allowed.

The development of this on-stream reservoir should be compared with an alternative off-stream reservoir. This would require only a low diversion dam in the main stream with a low lift pumping plant for initial filling and replenishment of the reservoir drawdown during flood periods. This could be located closer to the City and would require the inundation and purchase of much less land area. A possible site for an off-channel reservoir is located about 3/4 mile south of the

City limits east of Highway 95. A large and relatively flat area lies on both sides of the stream and would provide for the development of a small reservoir with potential increase in size for future expansion. The drainage area at this location would be about 27 square miles (17,300 acres) and the average yield would be about 7,800 acre-ft with minimum yield about 3,900 acre-ft. It is probable that only a portion (possibly 50 per cent) of this could be recovered. An initial reservoir to store 2,000 acre-ft with 10-ft average depth would require about 200 acres of land and the construction of low earth dikes totaling about 12,000 ft in length. No spillway would be necessary, but a small overflow weir or outlet pipe would be installed to control maximum water level. Pumping from the main stream would only be necessary to replenish evaporation and water use and could be selective to avoid diversion during periods of high turbidity. The reservoir could be divided into primary and secondary settling basins before pumping into the City water system.

F - PROGRAM FOR DEVELOPMENT OF FUTURE SOURCES OF WATER SUPPLY

The water supply for the City of Moscow, with an average population growth rate of 2.6 per cent per annum and an increasing per capita use, should be programmed on a long-term basis with an over-all general plan to meet potential requirements for at least 25 years and a more definite short-range plan to meet near future demands of 5 to 10 years' growth. The adopted plan should be proportioned to the ability of the community to finance the projects from prospective water revenue without substantial increase in rates. The program should be designed for incremental development in economically feasible stages which will require minimum investment and operating costs.

The long-range plan will include development of both ground-water and surface-water sources and should have flexibility for acceleration or deceleration of the schedule of installations to meet changing conditions. The prospects of population influx from industrial and agricultural activity with expanded University enrollment within the next 25 years should offer

the incentive to investigate all possible water supply sources in order to evaluate their economic merit and determine their adaptability in the overall plan. In order to attract new industry and preserve the integrity of the community, the water supply must at all times be adequate and reliable with sufficient reserve capacity to assure continuity of service. The quality of the water should be satisfactory for potable use without need of expensive chemical treatment.

The City and University estimate of water requirements appears to be reasonable and conservative with consideration of all influencing factors. It appears that by 1965 the annual requirements will be from 800 million gallons (2,500 acre-ft) to 1 billion gallons (3,000 acre-ft), with maximum demand from 4.53 mgd (3200 gpm) to 5.66 mgd (4000 gpm). Only a small addition to the existing well supply is necessary to satisfy these requirements. By 1985 it is estimated that annual requirements may reach approximately 1.5 billion gallons per year (4,500 acre-ft) and maximum demand 7.45 mgd (5200 gpm). Present planning should consider water supply sources adequate for a total capacity of about 6,000 acre-ft, which will allow some margin for reserve and unforeseen demand.

The development of a supplemental supply of surface water by the construction of storage reservoirs for impounding flood waters now going to waste appears to be the logical means to assure meeting the long-range requirements. The joint use of surface-water sources with ground water would provide a means of relieving the draft on underground storage and permit some recovery of water levels. Seepage and release of excess water from the reservoirs may also aid in the recharge of the aquifers.

With present use of approximately 2,000 acre-ft per annum, it is questionable if any large additional supply of water may be obtained from ground water within the Moscow city limits. However, it is possible that the additional capacity required for the immediate future can be obtained from deeper and more widely spaced wells which may intercept underground flow not being reached by the existing wells. The increase of groundwater yield by new wells drilled within reasonable pipeline distance to the City and University storage tanks would be the most economical means of stabilizing the present supply and taking care of near future water requirements. Consequently, a program of exploration to obtain suitable locations for additional wells should be undertaken concurrent with the investigation of sources of surface water.

1 - Additional Exploration of Ground-Water Sources

The extent and depth of the underlying aquifers are unknown and it would be desirable to make additional exploration by the most practicable and economical methods - preferably with the collaboration of USGS geologists and experienced hydrological engineers.

The present redrilling of Well No. 6 located in the north end of the City should do much to reveal the character of the deeper strata. If a satisfactory water-bearing formation is encountered in or below the lower basalt, an electric log can be made at a cost of from $ 500 to $ 600 which will supply information regarding the location, thickness and porosity of the formation and chemical quality of the water. Several types of electric logging equipment are available for this purpose. The resistivity method is generally used for uncased holes, and gamma ray equipment for the cased portion of the hole. The choice of method and interpretation should be made by a qualified ground-water hydrologist.

If Well No. 6 is successfully developed as a permanent well, a carefully controlled pumping test should be made to determine the specific yield and hydraulic characteristics of the aquifer, such as coefficients of transmissibility and storage. The transmissibility of a formation is related to its permeability and the coefficient of storage is a measure of the quantity of water given up by the aquifer when the hydraulic head is lowered. The pumping test should be at a constant rate with accurate measurement of drawdown and recovery in the pumped well and one or more wells at some distance from the pumped well. Knowledge of the hydraulic characteristics will enable determination of the safe yield of the aquifer for sustained pumping during future years and the amount of water which can be released from storage.

Test hole drilling to explore the depth and extent of the aquifer along a line approximately transverse to the direction of underground flow is the most positive method of locating additional wells. The use of the rotary method should be investigated as this permits the drilling of a small-diameter hole in the shortest time. If a satisfactory water-bearing formation is obtained, it may be used as a pilot hole for the developed well.

It is suggested that an initial test hole be drilled south of the City limits in the lowest point in the valley of the South Fork of the Palouse River -

approximately 1-1/2 miles due south of the present pumping wells. Another test hole may be drilled at a later date approximately 1 mile north of the present pumping wells and adjacent to the north-south Highway 95. Correlation of drillers and electric logs of each of these test holes with known data from existing wells should provide information regarding continuity of aquifers and slope of the piezometric surface.

If further investigation indicates the feasibility of geophysical exploration using seismic or electric resistivity methods, a continuous profile along this north-south line and transverse in an east-west direction will provide information for location of other wells to fully exploit the ground-water resources in the Moscow area.

2 - Investigation of Alternative Plans for Supplemental Surface Water

Regardless of the outcome of the ground-water explorations, it is inevitable that supplemental supply for future long-range needs must come from surface water sources. The average yearly runoff of the surface streams in the Moscow basin is estimated by USGS hydrologists to be about 12,000 acre-ft (3.9 billion gallons). The minimum yield will be considerably less (about 50 per cent or 6,000 acre-ft); probably only a portion of this can be feasibly impounded in reservoirs for City use. Eventually all of the available surface water sources can be utilized by the City and their economic merits should be determined.

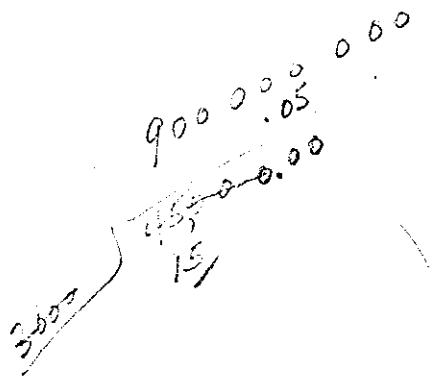
It is, therefore, essential to proceed as soon as possible with the investigation and determination of the most economical sources for initial and successive developments. Engineering investigations, water permit negotiations, acquisition of land and design of suitable surface water projects usually require several years' advance planning. The availability of alternative sites for reservoirs on the tributaries and main stream of the South Fork of the Palouse River and Paradise Creek, with varying distances for transporation of stored water, makes it necessary to compare over-all project costs.

Unfortunately, topographic data is not available for even preliminary estimates of costs at the present time. An over-all topographic map of the Moscow basin is desirable for long-range planning. Steps to promote this through the County, State and Federal Governments should be undertaken

as soon as possible. In the meantime, aerial photogrammetric surveys can be made of potential sites for on-stream and off-stream reservoirs.

The Robinson Lake Site appears to have considerable merit for early investigation and a preliminary ground survey has been made of the dam site and reservoir area. A permit has been obtained for appropriation of water and it would be possible to obtain other field data for an engineering study of this site without delay.

The site appears attractive and economically feasible as a source of supplemental water supply. A rough approximation of cost indicates the dam, reservoir and pipeline for storage of 900 million gallons (2,700 acre-ft) could be built to deliver water to the City for less than $ 0.05 per 1,000 gallons. The quality of this water is unknown, but surface water obtained from headwater reservoirs is usually soft and palatable and if protected from contamination should improve the potability of the water supply for the City and the University.



APPENDIX A

Data on Moscow Wells

DATA ON MOSCOW WELLS
(Not including those operated by University)

Well No. 1 Located at central pump station. Hole 12 inches in diameter. Depth about 240 feet. Byron Jackson Deep Well Turbine with 75 hp motor, installed in 1931. At time of installation, pump delivered 600 gpm. Now delivers about 400 gpm (No meter). New pumping unit (Lewis) installed in 1945. Pump column lowered about 36 feet in 1956. Used only as stand-by and for street flushing purposes.

Well No. 2 Located at central pump station. Hole 15 inches in diameter. Present depth about 250 feet. Layne & Bowler Deep Well Turbine pump with a 125 hp motor, installed in 1951. At time of installation, pump delivered 950 gpm. Capacity of pump reduced to 600 gpm late in 1957, due to sand condition and holes in casting of bowl assembly. New bowl assembly installed in January 1958. Sand eliminated by concreting. Test showed pump delivering 1150 gpm with new bowl assembly, with power demand of about 125 hp. Pump now delivering about 1100 gpm.

Well No. 3 Located at central pump station. Hole diameter 15 inches. Depth about 280 feet. Byron Jackson Deep Well Turbine Pump with a 150 hp motor, installed in 1931. At time of installation pump delivered 1250 gpm. New bowl assembly installed in 1945. Pump column lowered about 36 feet in 1956. Test showed pump delivered about 1400 gpm, with new assembly, and now delivers about 1350 gpm. Motor is operating at about 90 per cent of rated capacity.

Well No. 6 Located about 1/2 mile northerly from the central pump station. Drilled in 1955. Depth 280 feet. Diameter of hole at 250 feet is 19 inches. On test, well produced about 1500 gpm. Pomona Deep Well Turbine Pump rated capacity of 800 gpm with 150 hp motor (excess power to allow for increasing capacity of well) installed in 1956. Well delivered about 1000 gpm during 1956 and up to spring 1957. Flow gradually reduced to 275 gpm during summer 1957; pump removed. Hole is now being drilled to a lower depth to strike lower level of water. Hole now drilled to a depth of 930 feet. Basalt structure from 900 to 930 feet, this being the third layer of basalt encountered from the surface downward.

Water in all of the above described wells apparently derived from lower level of top basalt layer or just below said strata, at about 250 foot level.

DATA ON MOSCOW WELLS
(Not including those operated by University)
(Continued)

Moscow lies in an artesian basin. The static water levels since about 1892 are as follows:

1892	Near ground surface elevation
1923	Depth of 42.5 feet
1930	Depth of 50.0 feet
1931	Depth of 54.0 feet
1940	Depth of 74.0 feet
1951	Depth of 85.0 feet
1958	Depth of 90.0 feet

(Accompanying letter of December 1, 1958 from H. J. Smith, City Engineer)

APPENDIX B

Estimate of Future Water Requirements

ESTIMATE OF FUTURE WATER REQUIREMENTS
(In million gallons)

	CITY OF MOSCOW				UNIVERSITY OF IDAHO				TOTAL REQUIREMENTS			
	A	B	C	D	A	B	C	D				
Year	Estimated Total Annual Requirement	Estimated Maximum Daily Requirement	Possible Total Annual Requirement	Possible Maximum Daily Requirement	Estimated Total Annual Requirement	Estimated Maximum Daily Requirement	Possible Total Annual Requirement	Possible Maximum Daily Requirement	Total A Columns	Total B Columns	Total C Columns	Total D Columns
1958	404	1.54			190	1.12			594	2.66		
1960	461	2.21	576	2.76	204	1.59	255	2.00	665	3.80	831	4.76
1965	529	2.54	660	3.16	272	1.99	340	2.50	801	4.53	1000	5.66
1970	592	2.84	740	3.55	321	2.19	401	2.74	913	5.03	1141	6.29
1975	658	3.15	822	3.94	335	2.24	419	2.80	993	5.39	1241	6.74
1980	712	3.41	890	4.27	354	2.30	442	2.87	1066	5.71	1332	7.14
1985	753	3.61	941	4.51	370	2.35	462	2.94	1123	5.96	1403	7.45

Note: Maximum daily requirements would occur during the months of July and August.

ESTIMATE OF POPULATION GROWTHS

Year	City of Moscow	University of Idaho	Total of Both
1950	7,320	3,273	10,593
1958	9,360	3,916	13,276
1960	9,950	4,009	13,959
1965	11,400	5,494	16,894
1970	12,770	6,487	19,257
1975	14,180	6,770	20,950
1980	15,350	7,190	22,540
1985	16,250	7,500	23,750

Note: Estimates of water requirements in the future do not include the requirements of possible future industrial installations, nor do estimates of population growths include employees of these industrial installations who might be living in Moscow. The Anaconda Copper Company is considering the installation of a clay processing plant in Latah County, possibly in the Moscow area. Even though not located in the Moscow area, some of the employees would live in Moscow, particularly the supervising personnel.

(Accompanying letter of December 1, 1958 from H. J. Smith, City Engineer)

These figures were compiled for EBASCO Services in 1958, the water requirements should be fairly accurate, but the population figures are high and have been recalculated on the accompanying sheet.

KES
Sept 12, 1962

Appendix B