PRELIMINARY REPORT
ON THE MANUFACTURE OF
PHOSPHATE AND POTASH FERTILIZERS
IN THE ELECTROCHEMICAL BASIN
AT GREEN RIVER, WYOMING

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Cheyenne, Wyo.
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PART I

CHAPTER I

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PHOSPHATE ROCK RESERVES

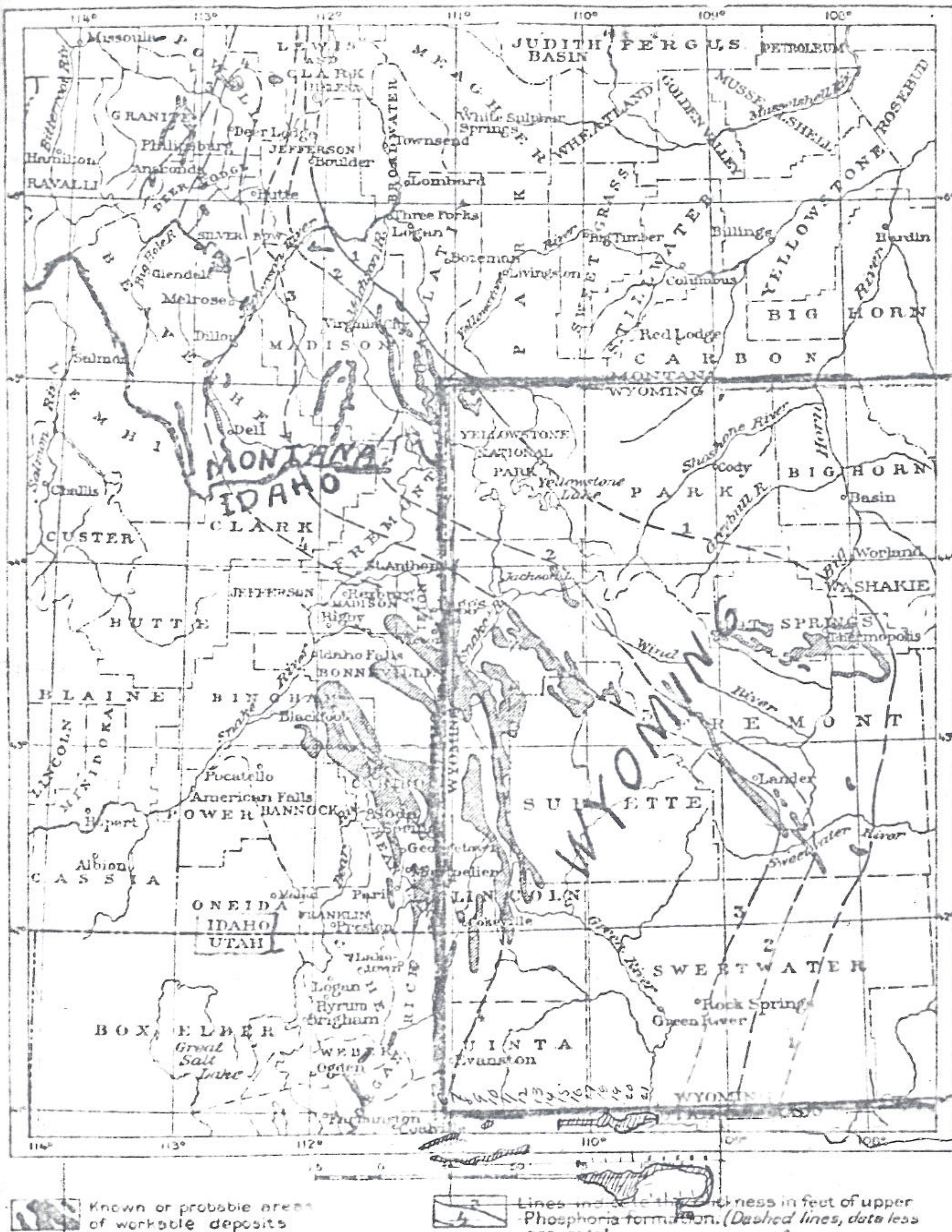
The World - United States - Western Fields - Wyoming

In his message delivered to Congress on May 20, 1938, the President of the United States estimated the known supply of phosphate rock in the world at 17,200,000,000 tons. Of this total, no less than 7,200,000.000 tons were accredited for the reserves of the United States. Our deposits therefore slightly exceed 40% of the world's tonnage. Containing only 6% of the world's area and 7% of its population, our share of this crucially important plant food may be deemed adequate for many centuries yet to come.

In the President's message, 90.8% of the vast phosphate reserves of the United States were alloted to one region, generally known as the Western or Inter-Mountain phosphate fields. A map of these fields, long recognized as containing 36% or more of the world's phosphate rock, is published in Bulletin No. 795 of the United States Geological Survey. A photostatic copy of this map appears on the following page.

A glance at the map insert shows that the western boundary line of Wyoming divides the western phosphate fields into two equal parts. Those lands that are cross-hatched in black are recognized by the Survey as phosphate bearing in character. One half of those so designated areas appear in Utah, Idaho, and Montana, and the remaining half, wholly within the boundaries of the Sovereign State of Wyoming. Exact figures on the acreage totals of the four states will appear in tabulated form in the following chapter - "Phosphate Land Withdrawals."

In addition to the four Rocky Mountain states, phosphate rock has long been mined in five eastern states. The available tonnages for all states are separately tabulated on page 292 of



MAP SHOWING EXTENT OF WESTERN PHOSPHATE FIELDS

USGS Professional Paper, No. 152, published in 1927 under title, "Geography, Geology, and Mineral Resources of Part of Southeastern Idaho." These listings follow below:

TABLE 74a.-Estimate of phosphate rock in the United States available December 31, 1925, in long tons

Field	Estimated quantity available	Field	Estimated quantity available
Eastern field:*		Western field:	
Arkansas	20,000,000	Idaho	4,997,855,000
Florida	291,000,000	Montana	391,323,000
Kentucky	878,000	Utah	326,745,000
South Carolina	8,788,000	Wyoming	115,754,000
Tennessee	83,500,000		5,831,677,000
	404,166,000	Less approximate quantity mined since 1906	350,000
			5,831,327,000
			404,166,000
			6,235,493,000

*Figures for the eastern field revised from author's chapter on Phosphate rock, U.S. Bur. Mines Mineral Resources, 1924, pt. 2, p. 88, 1925, to allow for decreases on account of rock mined.

The foregoing tabulation discloses that the Western tonnages greatly exceed the reserves of the long exploited Eastern fields. The Wyoming tonnage, however, is the lowest accredited to the four Western states. Please note that the Survey tabulation is dated December 13, 1925. Subsequent prospecting operations have increased the national reserves nearly one billion additional tons in the ensuing 13½-year interval. Such findings are not surprising. Elsewhere in the cited Survey publication, the author regards his 1925 reserves estimates for the Western phosphate fields as "conservative and incomplete."

The measured phosphate reserves of Idaho greatly exceed the totals of the three remaining states. The Idaho publication of the Survey is still looked upon as the most valuable and comprehensive volume so far published on phosphate deposits. Its value as a reference work will continue for many years.

The 115,754,000 tons of phosphate rock accredited to

Wyoming is not subject to revision in this report. Only one of the five Eastern states in which phosphates have been mined for many years is recorded with greater reserves than Wyoming. Probably 25 years will pass before the newer soils of the West will consume 250,000 tons of phosphate annually. If all of that rock was mined in Wyoming, the supply of the state would last for 400 years.

For upwards of 30 years or more, raw phosphate rock has been mined in Wyoming and adjoining states. The producers have generally failed to receive more than $4.00 per ton for their rock. Within the past 10 years, Wyoming sugar beet growers have paid as high as $60.00 a ton for the processed product. This price differential has seriously hindered phosphate consumption in the state. Nevertheless, only one factor will justify the construction of a phosphate works in the Western field. Technological staffs will have to be convinced beforehand that the rock can be reduced here at a lower cost than at any other point in the U.S.A.

In selecting a site for a reduction plant, no geographic factor will likely receive more consideration than the line that forms the western boundary of Wyoming. That line is the central axis of a region recently recognized by high authority as the greatest depository of phosphate rock in the world. The boundaries of Wyoming, Idaho and Utah meet at one point on that medial axis. Within a 15-mile radius of that common point, huge quantities of phosphate rock seem to abound in every cardinal direction of the compass.

Today, industrial sites are chosen strictly on an engineering basis. For the operation of a phosphate plant at the low-cost site it would seem immaterial if the raw rock supply came from Wyoming, or say, from points distant no more than 10 or 15 miles beyond its western boundary line. Some pipsqueaks may take exception to this policy, but the potentialities of Wyoming are of a broad and diverse character. If public funds are utilized to develop the western phosphate fields, it would not be essential for Wyoming to grasp at every available monopoly. As a matter of equity, the Western fields are of ample dimension for several states to share in the benefits of a sizable development program.

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CHAPTER II

PHOSPHATE LAND WITHDRAWALS

Status of Western Phosphate Lands - Polar Zone Precedent

One-half of the land still owned by the Federal Government that is classified as phosphate bearing in character is located in Wyoming. The latest summary available on the status of these lands is recorded on page 214 of the USGS Professional Paper, No. 152, previously cited. Extracts therefrom follow:

Status of Western Phosphate Lands

"In Utah, Idaho, Wyoming, and Montana the great bulk of the phosphate rock is on public land, though some has passed into private ownership. The public lands are withdrawn from entry pending their examination and classification. No estimates of the acreage of phosphate land in private ownership are available, but the acreage of the outstanding withdrawals of public land in the States named is shown in Table 38.

TABLE 38.-Outstanding phosphate withdrawals, July 31, 1927

	Acres
Utah	301,945
Idaho	396,612
Wyoming	996,539
Montana	279,944
Total	1,966,390

In addition to the land embraced in the outstanding phosphate withdrawals, 268,299 acres in Idaho, 25,293 acres in Wyoming, 3,833 acres in Montana, and 160 acres in Utah--297,585 acres in all--have been examined in detail and formally classified as phosphate land. The total classified and withdrawn lands thus amount to 2,263,975 acres. The classified lands include 4,080 acres in the Fort Hall Indian Reservation, Idaho, and 20,576 acres in the Wind River Indian Reservation, Wyo. The figure just given for total classified and withdrawn lands does not include phosphates of Mississippian age, except those of the Laketown district, Utah, or the deposits privately owned. Not all this territory contains high-grade rock, but the estimates on page 292, which are conservative and incomplete, show that a vast tonnage of high-grade rock may be expected."

A map showing the western portion of the Wyoming phosphate land withdrawals appears on page 8, of USGS Bulletin, No. 680. It is inserted on following page. For approximate locations of

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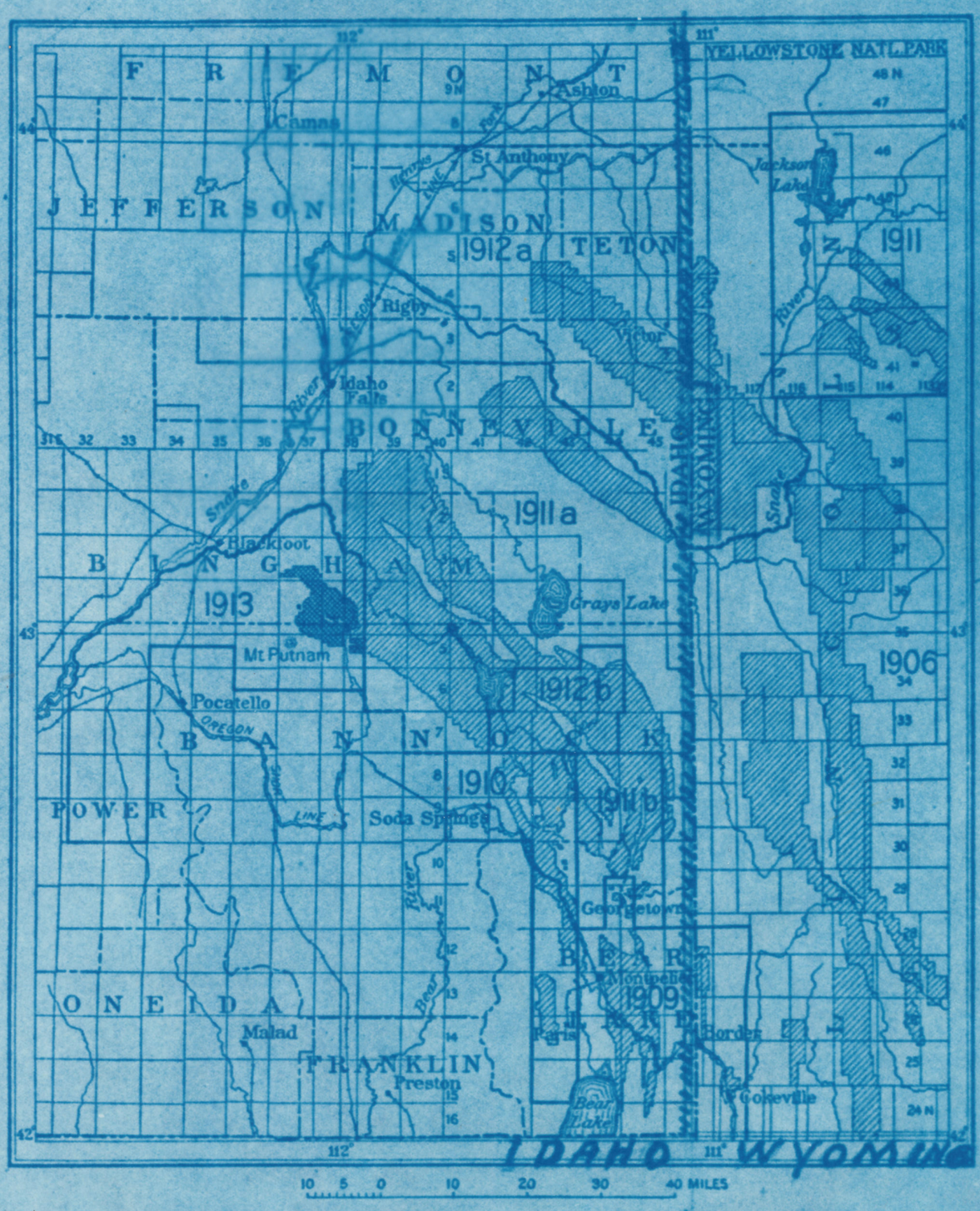


FIGURE 1.—Map showing areas examined by the United States Geological Survey and the extent of phosphate reserves in eastern Idaho and western Wyoming on July 1, 1914.

remaining Wyoming withdrawals, reference may be made to the map previously inserted in this report.

The foregoing incomplete tabulation discloses that over one-half of the Federal phosphate withdrawals are in the single State of Wyoming. The supplemental figures show that the Wyoming total is more than a million acres. In other words, one acre out of every sixty in Wyoming is under the form of proprietorship here described. It is not surprising that our author made the statement--

> "Not all this territory contains high-grade rock, but the estimates on page 292, which are conservative and incomplete, show that a vast tonnage of high-grade rock may be expected."

When appraisals can be completed in years to come, it is possible that the phosphate rock tonnage now accredited to Wyoming will be considerably augmented.

There is good reason to believe that the preceding withdrawals cover more than 90% of all the phosphate bearing land so far discovered within Wyoming. In this state, the Federal Government likewise exercises a similar degree of proprietorship over vast potash deposits, coal, gas and oil fuels, hydro-electric works, and to other varieties of raw chemicals that enter into the fertilizer industry. From such a complete diversification of natural resources, not only phosphates but every type of mineral fertilizer could be manufactured at price levels far more attractive than those prevailing elsewhere.

Should proprietory equities decide the site of the proposed reduction works, the rights of Wyoming would surpass the total of all remaining states. Ownership to such huge acreages of mineral lands involves certain responsibilities, one of which is the factor of development. In years past, a number of Wyoming Statesmen delivered orations on the evils of absentee landlordism. To permit such lands to remain in a perpetual state of inactivity, causes a spirit of discontent to arise now and then in certain communities of the state.

Polar Zone Precedent

Tabulations, hereinbefore filed, unmistakably prove that the largest single owner of rich phosphate lands in the world is the United States Government, itself. For a part-way comparable precedent, it is necessary to go to the records of a Communistic or Totalitarian ownership state. In its quest for phosphates, Russia startled the chemical industry less than ten years ago with the announcement that it was going to construct a treatment plant considerably north of the Arctic Circle. Their declaration was greeted everywhere with sharp shafts of sarcasm. Scientists and economists promptly assured the Soviets that nothing but a complete financial fiasco was in store for an experiment so bold and unexampled. Nevertheless, all of those dire warnings were completely disregarded. By 1931, a $4,000,000 factory was opened for business on the forlorn slopes of the Khibiny Mountains in the Kola Peninsula at a point approximately 100 miles inland from the Arctic Ocean. The locality approximates the latitude of the northernmost tip of Alaska. Apparently, the agricultural potentialities of both regions are similar. Both lie well beyond the limits of arborescent vegetation Scenery in the immediate vicinity of the plant site was described by an American specialist returning at that time as follows:

> "Huge stone remnants of the glacial periods block the entrances to the valleys. The peaks are covered with perpetual snows and dreary tundra lies for hundreds of miles around."

The "North Pole" plant of the Bolsheviks was designed to handle Apatite, a phosphate mineral decidedly inferior to types that abound in Wyoming and other Inter-Mountain states. Interest in the history of this plant widened from year to year. The Mineral Year Books published by the U. S. Bureau of Mines report annually increasing outputs for each succeeding year ever since the works were completed in 1931. On page 1325 of their last annual the following statement appears:

> "The U.S.S.R. (Russia) is an important producer of phosphate rock, due largely to its Kola Peninsula Apatite deposits, although in 1935 it is reported to have produced 1,750,300 tons of low-grade phosphate rock."

Earlier annuals of the Bureau record equally brilliant achievements for the Polar Zone factory of the Bolsheviks. Exports from the Arctic ports to the International markets are recorded to range upwards from 26,362 tons in 1932 to 233,095 tons in 1935, the last year of available statistics. Inspection of other tabulations indicate that sizable portions of those shipments reached United States ports. One page 1323 of the last annual all but $15 of the phosphate rock imported into United States in 1936 is accredited to Russia as the point of origin. Earlier Federal year books review prolonged litigation instituted in the Higher Courts to keep out that type of merchandise (Arctic apatites) from the United States. In time, more domestic phosphate plants may prove to be the lesser evil for the dispensation of problems of the international gravity mentioned.

Domestic phosphate economists who formerly devoted most of their time to making fun of the Russian operations are now chiefly engaged in attacking proposals for a phosphate plant in a region as remote and isolated from civilization as the Wyoming Wilderness. The Soviet experiment can no longer be lightly dismissed. It demonstrated that lowly phosphate rock could be mined at points nearer the North Pole than any other type of ore supply. Original plans of the Bolsheviks called for the construction of an elaborate system of rail and auto-roads. To house the workers, a city for 12,000 to 14,000 people was projected upon the permanently frozen sub-soils of a region in which only one family of an Eskimo-like species formerly resided. Present output of the plant would indicate that a major share of its original grandiose plans has already materialized in a substantial manner.

Ability of the Russian output to reach the far flung markets of the world is not surprising. In later passages, it will be maintained that tax-free, royalty-free rock similarly mined from the huge Phosphate Land Withdrawals in Wyoming will travel considerably farther than analogous material heretofore excavated exclusively from costly private holdings.

CHAPTER III

GEOGRAPHICAL OPPOSITION

Editorial Criticism - Newspapers - Technical Journals

No longer can an investigation be made of the fundamental possibilities of Wyoming phosphate areas without encountering hostile criticism of diverse origin.

Much of the present anti-propaganda seems to have arisen within the past several months. As no one has yet filed a systematic protest against the growing opposition, this chapter is inserted with the view of freeing Wyoming from many disparagements so far directed against development proposals within the Inter-Mountain phosphate field.

Most of the disapprobation circulated to date is of a geographical character. In reality, Wyoming occupies the superior location on the western phosphate front. For withstanding verbal attacks, the positions of Wyoming are considerably stronger than those erected for the Inter-Mountain phosphate field as a whole.

Editorial Criticism - Newspapers

At this time, two radically different schools of thought have apparently succeeded in splitting the hitherto peaceful phosphate industry in twain. One branch is headed by lay newspapers published in the great Metropolitan centers. In a recent editorial in the New York Times, the perils of constructing processing plants in regions like the Wyoming Wilderness were fully set forth. According to their theory, no new works should be built at points remote from markets, already highly developed. If all new plants must be constructed in the centers of large plantations, it would seem that future expansion with the industry will be solely confined to two states. For after eliminating the four Western states from the National picture, we find that only Florida and Tennessee produce phosphates in volumes sufficient for their own requirements.

Space will not permit a digest of the mountainous mass

of criticism that has accumulated since a phosphate plant was first suggested for the Western field. Much of it is too superficial to warrant a review. If the lay press would display one scintilla of sincerity, it would seem that their "Doctrine of Remotism" would be fortified by actual facts and figures. At this belated day, plenty of specific precedents are available for exposure.

Hereinbefore, the domestic and international economics of a new plant operating a thousand miles from nowhere, and in a region barren of all agricultural possibilities whatsoever were briefly cited. The operations of other remotely located plants may later receive mention in this report. Until newspapers will present reviews, either pro or con, on specific operations, their readers may safely skip the anti-propaganda so far published on Wyoming.

Technical Journals

Technical journals appear even less sympathetic to Western field proposals than the lay press. Preeminent in the current field of endeavor is "Chemical and Metallurgical Engineering." A sample passage from their recent editorial columns is selected for insertion below:

> "Unfortunately, Providence placed these Western phosphates in the Inter-Mountain country. They are of high quality. They can be processed by old or new methods. But they are too far from any market to warrant hauling them first to a processing plant and then shipping their products to the farmer or to a suitable point of export."

To file an exception against foregoing message of sympathy would be an act of ingratitude. An editorial parallel is, however, available. In 1934, "Chem and Met" fired far harsher blasts against the subsidized construction of a phosphate plant in the Tennessee valley. Apparently, much water has flowed over Wilson Dam in the meanwhile. Since 1935, no journal, scientific or otherwise, has sung louder paens of praise on the revolutionary achievements of the TENNESSEE VALLEY AUTHORITY than "Chem and Met," itself.

Annually, the foregoing journal awards a $1,000.00 plaque to an outstanding private corporation for its meritorious contribution to the advance of the chemical industry. This mark

of distinction is highly esteemed among the more progressive companies. Glance at the notation concerning that last award made on December 10, 1937:

> "Outstanding among the developments in chemical engineering which have come into fruition since the last Chemical Exposition is the large-scale production and utilization of elemental phosphorous. A research program initiated by the Monsato Chemical Company at its Ammiston, Alabama plant in 1935, and later extended to its St. Louis and Dayton laboratories, culminated this summer in the successful design, construction and operation of a unique electric-furnace plant in Tennessee. Monsato thereby becomes the nation's largest producer of phosphorous. Simultaneous research has also opened up a broad field of usefulness, literally a whole new chemistry of phosphorous in organic as well as inorganic combinations. Much more will be heard from this work in coming months."

Since last December's prize was awarded another major chemical company has started construction of a large electric-furnace plant for the processing of phosphate rock within the promising Tennessee field. It may be voted the 1938 industrial award. From year to year the kaleidoscopic expressions of Editor Kirkpatrick are followed with increasing difficulty. By 1943, the industry should become sufficiently stabilized with surplus capacity plants for a new Wyoming corporation to take the annual chemical award. Geographically speaking, a Wyoming site would not be more remote from the exact center of the Nation than towns in Alabama and Tennessee in which both Federal and private agencies have recently completed modern phosphate works. In time to come few areas will likely demand more phosphate tonnage than the National Breadbasket, itself. If a Wyoming works captures big-scale markets that still remain open on a parity basis, it would seem that only a slight amount of additional crow would need to be digested by editorial opponents.

CHAPTER IV

PHOSPHATE DIVISION OF THE TENNESSEE VALLEY AUTHORITY

Research Activities
Economic Investigations
Mandate of Congress
Wyoming Offers Room for Enormous Technological Advancement
The Schwartz Investigation Committee
Private Lands vs Government Withdrawal Land Operations
Basic Rock Costs and Cheap Hydro-Energy Dictate Plant Locations

So far phosphate products have been manufactured at only one point by the Federal Government. For processing Tennessee rock, the Tennessee Valley Authority (hereinafter referred to as the TVA) recently completed an electric-furnace plant at a cost of $4,000,000 at Wilson Dam, Alabama. A primary object of this construction was to provide a market outlet for the surplus hydro-energy previously developed on the Tennessee River by the Government, itself.

During the year past, TVA officials conducted studies on the industrial potentialities of the Inter-Mountain phosphate fields. So far, their findings have not been published. In several respects, the cost of processing rock would be considerable less in Wyoming than at the present plant on the Tennessee River. A few of the outstanding achievements of the TVA are indicated in the following summary.

Research Activities

The story of the phosphate division of TVA cannot be compressed into a few words. For establishing the crucial importance of phosphorous as the most essential mineral plant food, no agency has yet offered material proofs so sound and convincing. For causing phosphates to play a dual role and thereby eliminating the purchase of another costly mineral element, hitherto considered essential in the agricultural world, the group of TVA technologists again stand out in the forefront. Manifestly, such revolutionary experiments will visibly broaden the markets for manufactured phosphates. It is

hardly surprising that TVA recently broadcasted the following statement:

> "Yet it has been conservatively estimated that if the needs of the land were reasonably met, the United States alone would consume annually 10 times the phosphate now used in a year - - - -. Many students of the subject have urged restrictions upon the export of an element which is so necessary and so irreplaceable."

Should domestic production be increased 10 fold, the reserves of all eastern fields would be exhausted within the next 13-year period. By that time, the industry would be forced to conduct all of its mining activities and most of its manufacturing operations solely within the Inter-Mountain field in which 90.8% of the National supply still reposes, virtually unscratched. Perhaps, the phosphate problem is no longer as sectional as current preachments would lead us to believe.

Economic Investigations

The philosophy of TVA research and development covers wide fields of endeavors. Its studies are not limited to scientific problems alone. In order that the grower can purchase his phosphate at lower and lower costs, the economics of manufacturing are investigated down to the minutest detail. Should a new type of sack or container prove equally serviceable, it will be adopted even if the saving amounts to only a fraction of a cent. In the relentless campaign staged by TVA for lower cost phosphate, little time is lost before such savings are passed on to the consumer. Apparently, the customer of the project receives primary consideration under the existing administrative set-up.

Mandate of Congress

The Mandate of Congress that directs TVA to "improve, increase and cheapen the production of fertilizer and fertilizer ingredients" is chiefly responsible for the current invasion of major chemical corporations into the phosphate fields of middle Tennessee. For processing the rock, these private concerns pattern their plants along the new electro-thermal procedures that TVA first demonstrated their practicalness from laboratory to pilot-plant stage and beyond.

The Federal group of technologists constantly evolve stronger and stronger phosphatic compounds. At the May, 1938 convention of the Chemical Institute, Dr. Harry A. Curtis, Chief Chemical Engineer of TVA, announced that his organization will produce a new fertilizer carrying 65% of available phosphate / or an annual scale of 50,000 tons per year. Apparently, the new concentrate is three times as powerful as the 16 to 20% "super-phosphates" generally sold to farmers before TVA entered into the industrial picture. Scientific achievements of that magnitude widen the marketing fields of prospective Wyoming manufacturing sites several fold. Regardless of the reasoning of the School of Remotists, the cost of the fertilizer on the farm (per ton of phosphorous available for plant use) is less, due to lower freight rates on the proportionately stronger concentrate shipped.

Wyoming Offers Room For Enormous Technological Advancement

TVA technologists tell the world that "room still remains for enormous technical improvement in the manufacture of phosphate plant food." If TVA intends to step up their products to the final efficiency optimuum of 83.2%, a locality containing a far more variegated array of natural resources than Tennessee must first be sought. A single valley in Wyoming strongly resembles a huge dynamical and chemical laboratory. Of all spots in the world, in it alone is concentrated, in literally exhaustless volume, every known form of basic energizer, every raw material primary heretofore deemed essential for the manufacture of all types of mineral fertilizers.

The Schwartz Investigation Committee

A weekly smartchart recently criticized TVA for its "obscure financial records of the power program - - - and that no impartial technical appraisal and report of the fertilizer program ever has been made to the board or to the public." Lacking up-to-date figures, it is rather difficult for this report to file comparative cost data. This date is too premature to point out everywhere the dollars and cents that would be saved through the operations of a Federal phosphate plant at a more advantageous site in Wyoming.

A few weeks later a Senate Committee was appointed to investigate the records of the project. Critics of the TVA and of similar power projects in Wyoming and elsewhere will doubtlessly seek a megaphone in order to strenthen their voices as they offer testimony. However, Senator Harry H. Schwartz is a member of the present Committee. Before its findings are announced in January, 1939, all may remain assured that at least one hard-headed, business-man type of western progressive will have all available figures for concluding an "impartial technical appraisal" on the relative costs of operating phosphate works in both Tennessee and Wyoming. At least a broad and thorough investigation is assured of TVA by the form in which Congress phrased its resolution of inquiry.

Private Lands Vs. Government Withdrawal Lands

Among the charges that will be heard in the present battle is the price that TVA paid for its phosphate lands. Such criticism can be of little local interest. Had a similar project come to Wyoming in the first instance, it would have found literally at the back door of the plant-site, a million acres of rich phosphate bearing land already owned in fee simple by the Government, itself. That Wyoming acreage represents one half of the Government ownership in the Inter-Mountain field, the largest phosphate deposits so far recognized in geology. Obviously, a Federal phosphate plant could operate in Wyoming without tying up any portion of its funds in the acquisition of additional lands. Other vantage points would be occupied by a local project. All will agree that it would be entirely immune from the type of criticism now used to smear the TVA project.

As the Sovereign State of Tennessee was entirely free of Federal-owned phosphate withdrawals, it was necessary for TVA to enter into an extensive land acquisition campaign. To assure an adequate ore supply for operating the plants, options to rent or purchase outright were exercised on several of the better phosphate bearing areas of Middle Tennessee. Such procedures tend to raise land values especially in areas not known beforehand to contain exhaustless supplies of raw material. In recent years, industrial-

ization has made much progress in the Tennessee valley. Since the invasion of the TVA, two private concerns have, likewise, constructed sizable phosphate works in the valley. These subsequent private operations doubtlessly did their share in boosting Tennessee phosphate rock to price levels considerably above the National average.

Basic Rock Costs and Cheap Hydro-Energy Dictate Plant Locations

A report entitled "TVA Estimates Favorable Costs for Concentrated Superphosphate" was published in the November and December, 1936, issues of Chemical and Metallurgical Engineering. The authors were three of the Chief Chemical Engineers of the Federal project. After tabulating 16 separate items that enter into the manufacture of the TVA finished product, the following conclusion was recorded as to the relative importance of cost items:

> "It will be noted that cost of phosphate (rock) is 37.2% of the total cost and power 20.8%. Obviously, plant location will be dictated to a large degree by these two items, and, inasmuch as power used per ton of phosphate may be transmitted at very low cost compared with the cost of transporting the phosphate, a plant location near the phosphate deposits is indicated."

Tabulations appearing in the quoted report indicate that nearly two ton of raw rock was being used to make one ton of superphosphate. Today TVA makes a more powerful phosphate that will require more than 2 tons of rock per ton of finished product.

Opponents of Western plant proposals generally limit future marketing territory to a point midway between the TVA works at Wilson Dam, Alabama and the central area of the Inter-Mountain field. The more favorable geography of Wyoming reduces that intervening distance by at least 125 miles. Another local factor would shrink that commonly objected-to mileage more considerably. If TVA bought or leased its phosphate lands on a royalty basis of $1.00 per ton of contained rock supply, no critic would likely develop a severe headache over their style of primary investment

procedures. But different conditions prevail within the Wyoming field. Its huge Federal Phosphate Withdrawals would entirely eliminate royalty payments. This saving would cut the cost of the finished product at least $2.00 per ton. That amount would prove sufficient to penetrate competitive marketing territory to an additional depth of at least 200 miles.

Two factors may likely dictate the location of the next site for a Federal phosphate works. First, an unlimited supply of royalty-free rock; second, lowest cost energy directly from a Federal hydro-project. Localities that can provide both of these basic requirements at one shot are few and far between throughout the Inter-Mountain Phosphate fields.

Previously quoted official data discloses that the two foregoing items total 58% of the cost in the manufacture of the most essential mineral food consumed by plant life. Former geologists have repeatedly appraised the value of the royalty exempt phosphate lands owned by the Government in Wyoming at more than $100,000,000. Next year, the U.S. Reclamation Service will complete a $10,000,000 hydro-electric works in a nearby Wyoming locality. Basic equities of these huge magnitudes should prove quite sufficient by themselves to guarantee the manufacture of phosphates at the absolute rock-bottom cost level.

CHAPTER V

PHOSPHATE MINING

Wyoming Mines - Utah Mines - Idaho Mine - Montana Mine
Long Distance Transportation
Big Scale Phosphate Factory in Canada
Anti-Dumping Laws

For upwards of 30 years or more, phosphate rock has been mined in Wyoming. In view of the vastness of its deposits as well as their easy accessibility to railway transportation, it is not surprising that first mining operations within the Inter-Mountain field were conducted at the more outstanding sites in Wyoming.

Wyoming Mines

In Governmental literature first citations of actual mining operations appear in USGS Bulletin, No. 315, entitled "Contributions to Economic Geology, 1906." That publication takes notice of the pioneer small-scale operations that were then under way at Sage and Cokeville, Wyoming, and also at Montpelier, Idaho. These references have only a historical value today.

First official description of a sizable phosphate mining operation in the Wyoming field appears in USGS Bulletin, No. 430, entitled "Contributions to Economic Geology, 1909." It follows below:

"Development

> The mine at Cokeville, which has been developed by the Union Phosphate Company, consists of a series of tunnels run in on the strike of the main phosphate bed. The mining practice followed involves the breaking of the rock by overhead stoping; stopes are opened above the several tunnels through upraises; the rock is hard, and air drills are used in putting in the holes; the breaking is done with giant powder; the stopes are set with timbers and the rock or ore is allowed to settle between the timbers and drawn off by chutes into cars that in turn dump into the lower stopes, which are used for storage purposes, the ore being finally drawn off into the car on the lower level, which dumps into the outside bins for loading the wagons. Little work has been done in the upper tunnel, but the other three are each approximately 1,000 feet in length.
>
> Offsets were noted in the second and lowest tunnels. One has about 6 feet throw at a distance of approximately 50 feet from the entrance. Another, about 1,650 feet in and about 35 feet back from the the face of the tunnel, shows a displacement of unknown throw. An examination of the surface above the mine revealed the existence of a fault--probably

the same one that shows in the deeper parts of the tunnels, with a direction of N. 15° E. and a horizontal offset of about 55 feet to the northeast on the north side.

The section of the "main beds" is fairly constant, and its details and the distribution of the phosphate content are given in the section of the Park City formation on page 505. The portion mined and shipped at present is 5 feet 4 inches think with an average content of over 35 per cent of phosphoric acid, equivalent to 75 per cent of tricalcium phosphate."

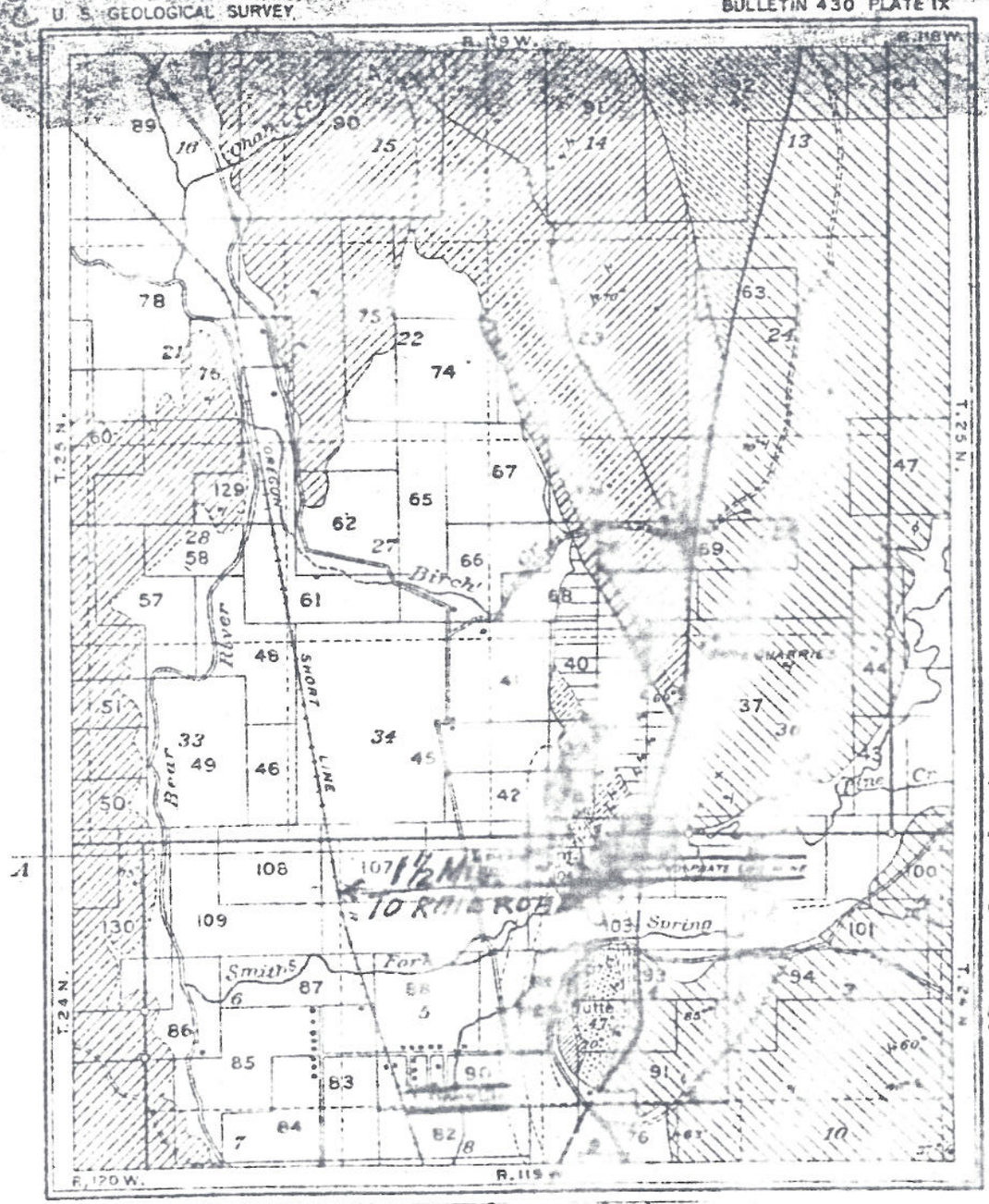
A geological map of the Cokeville phosphate area accompanies the preceding description. A copy of this map appears on the following page. It plots the Oregon Short Line, 1 ½ miles due west of the phosphate mine. The intervening distance is over a level flat.

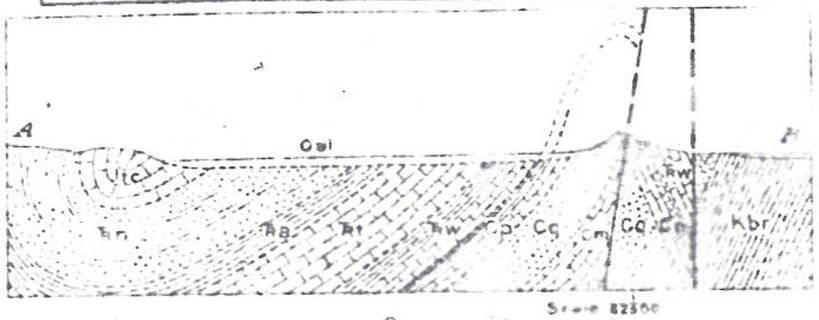
Next noteworthy description of Wyoming phosphate mines is in the USGS Professional Paper, No. 152, published in 1927 on Idaho areas. This comprehensive publication has been repeatedly cited, hereinbefore. It contains references on the past operations of three phosphate mines in Wyoming. An extract on the largest operation of that period follows below:

Cokeville Phosphate Co.-According to press statements* the Cokeville Phosphate Co. at Cokeville, Wyo., is growing rapidly and now markets its product in California, Oregon, and Washington. The phosphate bed is 6 feet thick and dips 75°. It is mined by the shrinkage system, and as it is taken out of stopes on the lower level it is filled in from a stope above. In this manner the lower stopes are always kept full of ore ready to be trammed out to the mill. About 100 tons are mined daily. The workings extend only 700 feet from the entrance of the lower tunnel. The cars run out by gravity to the mill. The rock is crushed, dried in a rotary drier until it contains less than 1 per cent of moisture, and is then pulverized so that 95 per cent of it passes a 100-mesh screen and 65 per cent of it passes a 200-mesh screen. The storage bins hold about 1,100 tons. A market for pulverized rock has been developed on the Pacific coast and since the output is sold on five-year contracts a steady demand is assured. With no excessive selling costs a low price is maintained.

The original plant was built in 1913. It is about 2 miles from the railroad and is completely electrified. In that year only 4 cars were shipped. In 1925, 149 cars were loaded. F. M. Breese is president and general manager of the company.

*Producing pulverized rock phosphate by the shrinkage system: Pit and Quarry, vol. 12, no. 2, pp. 85-87, Apr. 15, 1926.





Scale 62500

0 1 2 Miles

LEGEND

- Qal — Alluvium and talus
- Kbr — Bear River formation
- JKb — Beckwith formation
- Jtc — Twin Creek limestone
- Rn — Nugget sandstone
- Ra — Ankareh shale
- Rt — Thaynes limestone
- Rw — Woodside shale
- Pennsylvanian: a. chert; b. phosphate, shales, etc.; c. limestone — Park City formation
- Cq — Weber quartzite
- Mississippian: Cm — Madison limestone

JURASSIC CRETACEOUS QUATERNARY ? TRIASSIC ? CARBONIFEROUS

- Fault
- Strike and dip
- Vertical dip
- Dip nearly vertical
- Mine
- Prospect
- Tunnel
- Land corner found

PRELIMINARY GEOLOGIC MAP AND STRUCTURE SECTION OF THE COKEVILLE AREA, WYOMING

The two preceding extracts are of sufficient length to establish the sound type of geology on which the pioneer mining operations of the Inter-Mountain phosphate field were conducted. The recorded analysis, 75%, tricalcium phosphate is not surpassed by the ore bodies now being mined in the Western field. Only one larger mining operation is accredited to the Western field in the score or more Survey publications examined in the preparation of this report.

Utah Mines

Utah seems to be the only state of the Inter-Mountain field that has been free of phosphate mining operations in recent years.

About 30 years ago some development operations were under way a few hundred feet west of mile-post, No. 52, on the Wyoming-Utah line. The nearest railway point to this locality is Sage, Wyoming, a station on the Oregon Short Line. Apparently, no representative of the U.S. Geological Survey has reported on the locality since 1909.

Idaho Mine

The largest mine so far developed within the Western Phosphate field is located at Conda, Idaho. The latest description of the property in USGS publications appears on pages 236 and 237 of Proffesional Paper, No. 152. The following passages contain some comparable values in respect to Wyoming mines previously described.

> "The presence of a 7-foot bed that contains 70% of tricalcium phosphate may be safely assumed."
>
> "Because of the limitations just named it is necessary during development to follow the phosphate bed, which, since it is highly inclined, appears like a vein of lode, with a smaller heading, which is the same size as the ordinary Butte drift and is generally timbered in the same manner."
>
> "A branch of railroad about 8 miles long connects Conda with the main line of the Union Pacific Railroad just east of Soda Springs."

A glance at the preceding map of the Cokeville Phosphate area shows that Wyoming phosphate mines lie 4 times as close to mainline railroad tracks as the big mine in Idaho. Construction of the shorter branch lines decreases operating investment considerably. The railroad from which the 8 mile branch was completed to Conda, Idaho is precisely the same line that passes through Cokeville, Wyoming. In Wyoming it is generally referred to as a feeder line of

the Union Pacific Railroad.

The preceding extracts disclose that the Conda phosphate deposits are in conformity with the "highly inclined vein or lode" types previously described for the Wyoming mines. The width of the Idaho veins are recorded at 7 feet against the 5 feet 4 inches and 6 feet widths previously accredited for the Wyoming mines. Rock could be mined at a lower cost in the wider veins of Idaho; but the operation savings would only amount to a few cents on the ton.

The Conda mine is now the largest property operating in the Western phosphate field. It lies only 70 miles northwest of Cokeville, via railway. For reaching natural markets, a transportation advantage of at least 70 cents a ton is indicated for the Cokeville deposits.

The mine in Idaho occupies a favorable position for reaching the markets of the Pacific Northwest. Ever since the mine was opened at Conda, its rock has been shipped to a large processing plant at Anaconda, Montana. The intervening distance is 350 miles or considerably farther than phosphate rock is shipped, by rail, to processing plants in the older Southern fields. The distance between the mines and processing plant of the TVA is hardly half that far.

At no time have mining operations been conducted within the huge Inter-Mountain Phosphate field at a point closer to the exact center of the United States than Cokeville, Wyoming. This geographical factor will likely remain unchallenged for a number of years to come. For reduction at the lowest costs attainable in the West, the Cokeville rock would be hauled a distance of only 114 miles.

Heretofore, it has been the policy of manufacturers to select plant sites even more remote from National markets than the phosphate fields, themselves, and later, file complaints on the restricted buying power of their tributary marketing areas. A plant site in Wyoming would produce a contrary effect. For the first time the Western field itself would literally be transported an appreciable distance in the right direction. From its easternmost point of mining development, raw rock would be hauled an additional 114 miles in the direction of the big-scale markets.

The Cokeville mines are only 10 miles distant from the point where Wyoming, Utah and Idaho corner. Huge tonnages of high grade phosphates are known to occur in that vicinity. For plant operation, it would seem that any one of these states could provide an adequate rock supply. To date the superior railway facilities of Wyoming have decided the location of mines in that favorable Tri-State sector of the Western phosphate field.

After operating continuously for a period of 25 years, all phosphate mining was suspended in Wyoming in 1951. Output of the mines must have been considerable for in the later years, the Federal Bureau of Mines ranked Wyoming as the 4th phosphate producing state in the nation. Total production figures of the state are on file in the Bureau, but these tonnage records are not subject to inspection by the public at large.

Technological advancement seems to be solely responsible for closing down the mines in the Wyoming field. For many years, statistical annuals recorded the simple statement - - - "The Cokeville, Wyoming rock was used for direct application to soil." That form of assimilation never would produce more than a 2% efficiency rating, and such ineffective practices are now severely condemned by educational agencies like the TVA.

At this time only two mines are operating within the entire Inter-Mountain field.. Output of each mine is exclusively utilized for the manufacture of superphosphates that are approximately 50% efficient. One of these plants is owned by the largest Copper Mining Company in United States, and the other, by a similar concern operating in Canada.

Markets for the Wyoming rock apparently began to narrow in 1920. In that year, the Anaconda Copper Mining Co. completed an acid plant of 50 tons daily capacity at Anaconda, Montana for treating the rock mined from its Conda, Idaho phosphate properties. Formerly its smelter yielded large quantities of sulphuric acid fumes that could not be sold owing to distance from the market and high freight rates. An acid phosphate plant seemed to offer a natural outlet for the by-product theretofore unsalable. Since 1920, operating capacity has expanded several fold. In 1936, the plant treated 47,113 tons of rock mined from the company properties at Conda, Idaho.

That was the largest mining operation in the Western field in 1936, the last year of available statistics.

So far as known, all phosphates now sold in Wyoming are processed at the Anaconda, Montana plant. The 350-mile haulage from mine to processing plant, and even longer distances, that the soluble phosphates must travel to reach leading marketing areas of Wyoming is mainly responsible for the limited use of mineral fertilizers in the state.

A Montana Mine

Final exit of Wyoming from the phosphate mining field in 1931, may be laid to a huge phosphate manufacturing works that was opened for business in that year by the Consolidated Mining and Smelting Co. of Canada, Ltd., at their copper smelting site in Trail, British Columbia. Industrial operations at Trail and Anaconda are somewhat analogous. The Canadian works was built around a sulphuric acid plant having a daily capacity rating of 375 tons. Output of concentrated phosphatic and nitrogenous fertilizers runs as high as 456 tons daily. More than 225,000 horse power of hydroelectric energy has already been installed for the operation of the Trail enterprises. Most of this energy is doubtlessly consumed in the manufacture of ammoniated phosphates, a costly variety of fertilizer that seems to be already outmoded by findings recently published by the TVA group of research workers.

For their ore supply, the Canadian company takes the entire output of a phosphate mine located at Garrison, Montana. Export shipments from that mine in 1936 were recorded by the Bureau of Mines at 40,345 tons.

Long Distance Transportation

Opponents of development programs for the Inter-Mountain area frequently confirm the inability of phosphate rock to move any considerable distance between two points, provided, both points lie within domestic territory, exclusively. An earlier chapter maintained that figures are seldom submitted on how far analgous material sometimes travels to get into the U.S.A. At times, the same lowly type of ore supply is transported appreciable distances in order to get out of this country.

Pro and con arguments are already available for the solution of the Inter-Mountain transportation problem. On this debatable

issue, one propaganda organ filed two contrarious opinions within the past twelve months. Both follow below:

> "The Inter-Mountain Phosphates are too far away from any market to warrant hauling them first to a processing plant and then shipping their products to a farmer or to a suitable point of export."

Less than a year ago, the same journal mentioned:

> "Of outstanding interest to chemical engineers are the large and expanding chemical and metallurgical activities at Trail, B. C."

As agricultural endeavors do not appear noteworthy in the vicinity of prededing works the following rail mileages cover the route now followed by nearly 1/2 the output of the Inter-Mountain Phosphate fields:

Phosphate rock, from mine to smelter-site.	.541 miles
Superphosphates, from smelter-site to nearest ocean point of export.	558 miles
Total	1099 miles

The foregoing mileage total does not tell the entire transportation story. About 2 tons of rock are required to make a ton of high grade phosphate. On a ton-mile basis phosphates manufactured at a Wyoming point of origin might travel as far as Tennessee before freight bills would exceed the transportation charges of a phosphate operation now being successfully conducted in Canada. Recent annuals of the U.S. Bureau of Mines likewise account for current expansion activities at the foreign site notated in one of the last citations.

Big-Scale Phosphate Factory in Canada

The impressive developments at Trail entailed an expenditure of over $10,000,000, or more than twice the figure originally alloted by Congress for the construction of the TVA fertilizer plants. The Trail enterprise represents one of the world's largest investments within the fertilizer field. It may develop into Canada's largest chemical industry. If a similar plant was projected for this decidedly more preeminent agricultural nation, comparable populations would call for an outlay over 12 times as large.

Location of the site for the Canadian plant, likewise seemed to be contrary to all established rules of geography, clima-

tology and other vagaries of economic thought. Until quite recent years, it was hardly considered safe to construct sizable phosphate works outside of the state of Florida. A few old-timers are still of the opinion that application of such costly mineral food should be limited to their tobacco, cotton and citrus fruit lands,- exclusively. Production figures on the latter style of crops in Canada are yet unavailable. Perhaps, Our Lady of the Snows neighbor is convinced that phosphates could be applied even on her cooler soils with some visible degrees of profit.

Anti-Dumping Laws

Hereinbefore, some cognizance was taken of the drastic action that this nation utilized to exclude the products of a phosphate factory operated by the Soviet Republic north of the Arctic Circle from entering our shores. The big plant in British Columbia had barely begun to function before its operations were noted by the Anti-Dumping laws and machinery of this nation, along the lines of the following syllabus:

> "The Tariff Commission was directed by Senate Resolution 298, 72nd Congress, December 8, 1932, introduced by the late Senator T. J. Walsh of Montana to investigate under the authority conferred by section 336 of the Tariff Act of 1930 the difference in the foreign and domestic costs of phosphates, superphosphates and similar articles. On December 15, 1932, the Tariff Commission announced the institution of an investigation to carry out the requirements of the Walsh resolution. On August 19, 1933, the commission ordered a public hearing which was held on September 12, 1933 in Washington, D. C. The Anaconda Copper Co., United Metal Selling Co., and West Coast Fertilizer Tariff League presented data regarding the competitive situation between domestic and foreign superphosphates on the Pacific Coast of United States, claimed dumping of foreign superphosphates and asked protection for the Western domestic producers."

Apparently, the Walsh resolution was introduced to protect heavy investments in phosphate manufacturing works owned by Anaconda Copper Company in Montana. It is not stated that the resolution was aimed directly at the Trail works. But operations at the big plant in British Columbia were seriously constricted shortly after those proceedings were initiated. Since the low point of 1933, output volume of the Canadian plant has expanded more than 60 times.

The areas covered by the hearing proceedings formerly

constitued the marketing territory of the old and now inactive phosphate mines at Cokeville, Wyoming. As a matter of fact, their non-processed raw-rock outputs never did offer serious competition against the vastly superior phosphate solubles now being turned out by the big-scale works recently constructed on both sides of the Canadian boundary line.

CHAPTER VI

Mining Costs

Tennessee - Wyoming Contrasts
Production and Valuation Comparisons, Eastern Field - Western Field
Royalties, Taxes, Other Intangibles
Overhead Costs
Preliminary Estimate on Processing Costs
More Research Required

The western phosphate rocks are much like the Tennessee blues in appearance. They have the characteristic oolitic structure, and varieties so far mined in Wyoming are of a deep black color. The 75% tricalcium phosphate content hereinbefore accredited for the Cokeville mines appears slightly higher than analyses generally recorded for Tennessee operations.

Tennessee-Wyoming Contrasts

Two prior citations described the mode of occurence of rock so far mined in Wyoming. The Tennessee deposits occupy similar conformations. In both states, underground methods have been followed for mining the steep-dipping, well defined beds.

Unfortunately, the Tennessee beds are rarely more than 3 feet thick and usually less, and much barren material must be moved in order to approach the desired phosphates. By way of contrast, the mining operations hereinbefore recorded for the Cokeville, Wyoming district showed the phosphate beds to vary from 5 feet, 4 inches to 6 feet in thickness. In pay ore of those dimensions, no dead work at all needs to be performed. Being twice as thick as the Tennessee seams, Wyoming phosphate rock ought to be mined at half the cost of operation in the Tennessee field.

No current operating costs are available for Wyoming as no phosphate rock has been mined in the state during the 7-year period last past. Up to date figures are, however, available for Tennessee and Montana. The following comparitive data is assembled from tabulations appearing in the last Mineral Year Book:

Production and Valuation Comparisons

	Eastern Field		Western Field	
	Tennessee		Montana	
Year	Long Tons mined	Average Ton Value	Long Tons Mined	*Average Ton Value
1934	394,311	$4.26	2,086	$3.65
1935	493,501	$4.22	27,497	$2.68
1936	737,866	$4.04	*36,022	$2.11

*Only one company (Montana Phosphate Products Co., of Trail, British, Columbia) operated in the state. Its previously reported 1936 production (40,345 tons) were tons of 2,000 pounds.

Operating costs per ton decreased in both states as their production outputs rose from year to year.

Montana made the better cost per-ton showing. Its single mine expanded its output 1700% within the brief 3-year interval recorded.

Royalties, Taxes, Other Intangibles

Please note the foreign address of the present operator in Montana. It is doubtful if such a concern could do business in this state. Twenty-five or more years ago, about all of the known phosphate lands in Wyoming were thrown into huge land withdrawals. Such lands are now open for lease, but only, by domestic corporations or individuals. Before an alien concern could develop one of these sites, complicated legalities would have to be untangled, preferably ~~on the part of~~ by a constitutional lawyer.

The economic potentialities of the Western phosphate fields have thus far attracted resident and foreign capital alike. Much pioneer work remains to be done. For establishing the low cost mining record and for proving how far the Western rock can actually travel, credit must go to the foreign operator, exclusively.

A prior citation urged a restriction of the exportation of

an element - "so necessary and so irreplaceable as phosphorous." That theory may have provided the underlying motive for creating the huge withdrawals in Wyoming by Executive decree more than 25 years ago. Perhaps economists of that period foresaw the arrival of Federal research agencies like the TVA. Today, a million acres of this state are best suited for development by direct Governmental operations. Other states contain far less Phosphate Land Withdrawals. As such, they provide much greater latitude for exploration by foreign interests.

In the preceding tabulation, the 1936 rock costs for Tennessee and Montana are listed at $4.04 and $2.11, per ton, respectively. These listed per-ton values must include taxes, royalties, profits and other intangibles. The tabulation, however, is only good for comparative purposes, provided all listed figures cover private operations exclusively. There is a slim chance that the Montana mine was operated in a Phosphate Withdrawal. If so, 10 cents or more of its recorded valuation consisted of a royalty payment. No payment like that would have been included in the valuation total had the mine output been consigned direct to the TVA works in Alabama, instead of the less remote destination in British Columbia, previously recorded. For 1936 operations, rock valuation at the Montana mine appears to be slightly less than half of the Tennessee average, if a deduction is allowable for a Federal royalty payment.

Overhead Costs

In 1936, Tennessee's share of the domestic market for phosphate rock was 30%. The preceding tabulation indicates that the Montana output in that year more nearly equalled 1% of ~~that~~ the national ~~comparable.~~ consumption. As a matter of fact, all of the latter pioneer production was exported as ore supply for the operation of a distant foreign plant.

All will agree as to the unfairness of filing relative costs on the innovations of newly organized mining concerns with the technique and achievements accumulated by the old established firms.

Cut down the wide disparity in production totals that still exists between the 2 states selected for the comparison table. If the 1936 output of the Montana mine had reached 80,000 tons, in lieu of the 40,000 ton figure recorded, its overhead expenses would have been cut in two. That modest increase would have permitted an ore appraisal around the neighborhood of $1.89 per ton, F.O.B. at the mine. However, the $2.11 valuation still stands as the officially reported record for low-cost rock production for either the eastern or western branches of the American phosphate industry.

An unbiased interpretation of cost trends revealed in foregoing tabulation indicates the arrival of $2.00 rock within the Western division of the phosphate industry at no unduly distant date in the future. Ability to mine Western rock at half the national cost is not surprising. It is merely a matter of arithmetic. In Wyoming, the phosphate beds are twice the thickness of their narrow analogues in Tennessee. But mining achievements of the character hereinbefore tabulated are never cited in the anachronisms utilized by geographical obstructionists for proving the remoteness of Wyoming phosphate deposits from all possible markets.

Apparently, Dr. H. A. Curtis, Chief Chemical Engineer of the TVA has already devoted much thought towards the solution of transportation problems that have too long paralyzed the development of remotely located phosphate fields. His line of attack is based on technological advancement. Witness two of his findings that appeared in the April, 1938 number of Chemical and Metallurgical Engineering:

> "Where freight may be prohibitively high on a phosphatic material carrying 16% or even 45% P_2O_5 (phosphorous pentoxide) equivalent, it may still be feasible to ship elemental phosphorous having a P_2O_5 equivalent of 22%. o/o
>
> "The Monsato Chemical Co. is at present shipping elemental phosphorous in tank car lots from Tennessee to its plant in Anniston, Ala. and it would appear that shipment of elemental phosphorous will eventually be a factor in utilization of the great western deposits of rock phosphate."

Commercialization of procedures of the category indicated

would cut down freight rates on finished products from 70 to 80%. The reduction would be sufficient to permit the output of a Wyoming phosphate factory to invade the markets of not one, but each one, of the 48 states on an almost even competitive basis. Somewhere else, Dr. Curtis made the statement in effect - "there is room for enormous technological improvement within the phosphate industry." His preceding citations may be selected as prospective material for translation within the Inter-Mountain field of experimentation.

Preliminary Estimate on Processing Costs

About 7 years ago, present President of the American Potash Institute and 1938 Gold Medalist of the Academie d' Agriculture de France made the announcement that a high power potash phosphate, bearing an efficiency rating of 83%, could be manufactured at a certain site in Wyoming for the sum of $25.00 per ton. His appraisements were greeted in the technical press pretty much in the light of a pipe-dream. Boldest experimentation conducted to date by the TVA would indicate that even $40 phosphate pentoxide is yet unavailable on the market.

At that time, the U.S. Bureau of Chemistry and Soils was conducting a series of blast furnace investigations with the view of cutting down the farmers' bill for fertilizers, $60,000,000 annually. During the campaign, tests were made on raw materials from Wyoming and elsewhere.

The plans of the Bureau called for the assemblage of all requisite furnace ingredients at a natural focal point here in Wyoming. Included in the estimates were phosphate rock at $2.00 per ton, F.O.B. at the mine. However, at that early period no phosphate rock or other material appearing on the flow-sheet was available in the district at the extremely low costs recorded. Local optimists were soon left out on a limb, so to speak, when they took their turn to defend the economic merits of a plan then being attacked in widely separated quarters.

Some of the more far-seeing ex-defendents no longer

regard the pronouncement of the Bureau of Chemistry as being 100% premature. $2.00 phosphate rock already strongly illuminates the horizon of the Western phosphate field. In a prior citation that type of ore supply was disclosed as comprising 37.2% of the basic cost of operation at the big TVA works down on the Tennessee river.

The remainder percentage of the Plan does not appear altogether unsolvable, at least to some folks. Their operations in pure algebra, however, still contain too many variabilities for delineating definite curve trends on several commodities yet unquarried within their respective communities. In fact, one local type of ore supply has not yet been mined anywhere on an extended scale. Moreover, costsof other basic ingredients of the furnace charge have not been lowered appreciably since the Bureau announcement of 7 years ago. During the intervening time, outputs of those materials did not enjoy the degree of expansion activity recently accredited in Statistical Annuals for phosphate rock production in the Inter-Mountain fields.

More Research Required

Publication of spectacular announcements on technological advancement does not always produce a beneficial effect in every locality. At this belated day one community in Wyoming is still of the opinion that high power phosphatic compounds could be made in their locality and shipped to Alabama at a lower price than their present cost of manufacture at Wilson Dam. Their convictions will likely remain undisturbed until some agency goes to the bottom of a vast mineral store-house. In it are shelved the primary chemicals, all fluxing ingredients and all known types of thermal agents essential for the establishment of a hitherto unheard of enterprise - a 100% complete mineral fertilizer factory under a single roof.

All will agree that no man will perform by himself all of the variegated labors briefly sketched in the preceding lines. Merely to correlate the industrial potentials of certain groups of the foregoing minerals would severely tax the facilities of the biggest technological staff extant for years to come.

Wyoming is different than Tennessee. A wide deviation likewise separates it from all sister states that compose the Inter-Mountain Phosphate Province. In time the Wyoming type of research may completely emancipate America from European domination in the potash field. Of all states it promises the wider possibilities for transforming the American fertilizer industry into a completely self-contained economic unit.

One quarter of Wyoming closely resembles a huge dynamical and chemical laboratory. It is of sufficient dimension for housing any size technological organization yet assembled.

CHAPTER VII

G E O L O G Y

Potential Valuation - Geography More Important
Message of The President

No thesis need be filed on the geology of the Western Phosphate fields.

As stated before, these areas have long been known to contain the greatest deposits of phosphates so far recognized by the science of geology. By themselves they constitute 36% of the known phosphate rock supply in the world.

Much literature is already available on the geology of these Western Phosphate fields. In the preparation of the first section of this report, upwards to one ton of reference books were examined. Space precludes the listing of their titles.

POTENTIAL VALUATION

As stated before, the U. S. Geological Survey has already measured over 6 billion tons of phosphate rock in the Western Phosphate field.

Above the ground a ton of phosphate rock is worth considerably more than a barrel of oil. A little calculation discloses a higher potential value for the local phosphate rock than the appraisal now standing on all suspected oil reserves of the nation. The latter wealth is recorded by widely varying billions of dollars from year to year. The phosphate valuation is far more stabilized.

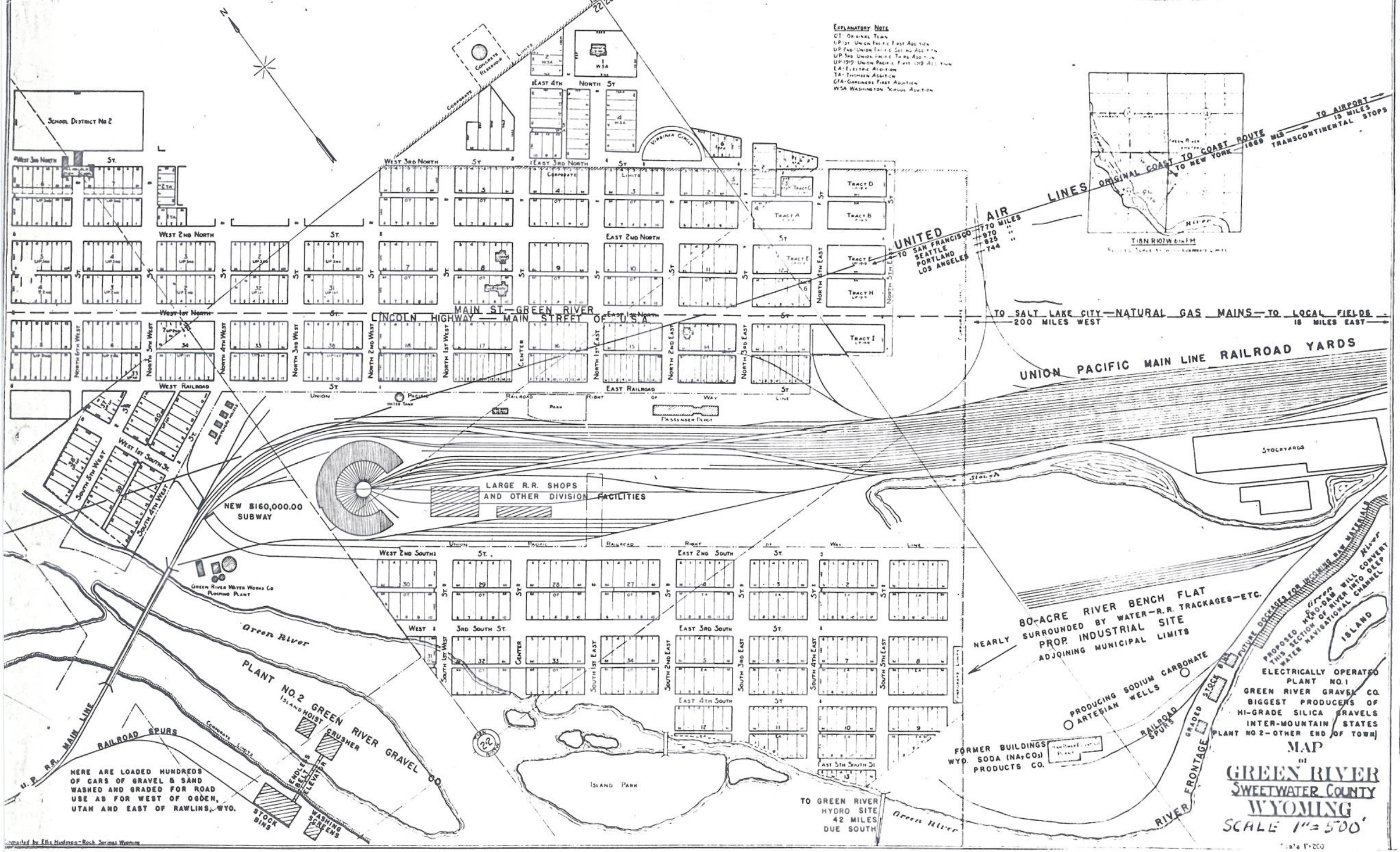
In some less favored areas of the nation a tributary industrial potential of the preceding magnitude would be looked upon with a high degree of favor. The day is not far distant when the real owner of these vast equities will be asked to stage a sizable program of development.

GEOGRAPHY MORE IMPORTANT

It is not necessary to build up a defense for the geology of the Western Phosphate fields. The intrinsic merits of these deposits have already been attacked by many types of detractors. So far no commentator has assailed the geology of the Western deposits. After admitting the exceptionally high quality of these rocks a previously cited propagandist popped at their geography as follows:-

> "Unfortunately, Providence placed these Western phosphates in the Inter-Mountain country"

Fortunately, it would appear, that the U. S. Geological Survey placed one-half of these phosphate bearing acreages in the less remote areas of Wyoming.


Explanatory Note
OT Original Town
UP 1st Union Pacific First Addition
UP 2nd Union Pacific Second Addition
UP 3rd Union Pacific Third Addition
UP 1919 Union Pacific First 1919 Addition
EA-Electric Addition
TA-Thomsen Addition
GFA-Gardners First Addition
WSA Washington School Addition
School District No 2
West 3rd North St.
West 2nd North St.
West 1st North St.
East 4th North St.
East 3rd North St.
East 2nd North St.
East 1st North St.
Corporate Limits
Virginia Circle
Tract A
Tract B
Tract C
Tract D
Tract E
Tract F
Tract G
Tract H
Tract I
MAIN ST.—GREEN RIVER
LINCOLN HIGHWAY — MAIN STREET OF U.S.A.
UNITED AIR LINES
TO SAN FRANCISCO 770 MILES
TO SEATTLE 970 "
PORTLAND 825 "
LOS ANGELES 744 "
ORIGINAL COAST TO COAST ROUTE
TO NEW YORK 1869 MLS
TO AIRPORT 13 MILES
TRANSCONTINENTAL STOPS
T18N R107W 6th P.M.
TO SALT LAKE CITY—NATURAL GAS MAINS—TO LOCAL FIELDS
200 MILES WEST
18 MILES EAST
UNION PACIFIC MAIN LINE RAILROAD YARDS
Union Pacific Railroad Right of Way
Passenger Depot
Pacific Water Tank
Park
Stockyards
LARGE R.R. SHOPS
AND OTHER DIVISION FACILITIES
NEW $160,000.00
SUBWAY
West 1st South St.
South 5th West
South 4th West
West 2nd South St.
East 2nd South St.
West 3rd South St.
East 3rd South St.
East 4th South St.
East 5th South St.
Green River Water Works Co
Pumping Plant
Green River
PLANT NO. 2 GREEN RIVER GRAVEL CO.
Island Hoist
Crusher
Endless Belt Elevator
Railroad Spurs
Corporate Limits
U.P. R.R. MAIN LINE
HERE ARE LOADED HUNDREDS
OF CARS OF GRAVEL & SAND
WASHED AND GRADED FOR ROAD
USE AS FOR WEST OF OGDEN,
UTAH AND EAST OF RAWLINS, WYO.
Stock Bins
Washing Screens
Island Park
TO GREEN RIVER
HYDRO SITE
42 MILES
DUE SOUTH
80-ACRE RIVER BENCH FLAT
NEARLY SURROUNDED BY WATER—R.R. TRACKAGES—ETC.
PROP. INDUSTRIAL SITE
ADJOINING MUNICIPAL LIMITS
PRODUCING SODIUM CARBONATE
ARTESIAN WELLS
FORMER BUILDINGS
WYO. SODA (Na_2CO_3)
PRODUCTS CO.
Railroad Spurs
Graded 10%
River Frontage
FUTURE DOCKAGES FOR INCOMING RAW MATERIALS
PROPOSED HYD-DAM WILL CONVERT
THIS SECTION OF RIVER INTO DEEP
WATER NAVIGATIONAL CHANNEL
Green River
ISLAND
ELECTRICALLY OPERATED
PLANT NO. 1
GREEN RIVER GRAVEL CO.
BIGGEST PRODUCERS OF
HI-GRADE SILICA GRAVELS
INTER-MOUNTAIN STATES
(PLANT NO 2—OTHER END OF TOWN)
MAP
of
GREEN RIVER
SWEETWATER COUNTY
WYOMING
SCALE 1"=500'
Compiled by Ellis Hudman—Rock Springs Wyoming

CHAPTER IX

THE SITE AT GREEN RIVER, WYOMING

Prior Investigations - Map - Publicity Sheet - Natural Resources Within Corporate Limits - Water Supply - Silica Gravel - Sodium Carbonate - Natural Gas - Sulphuric Acid

Several towns in Wyoming are now seeking the site of a phosphate reduction works. In fact, one newspaper has already announced that a Federal plant would locate in its city. That all of these towns possess certain local advantages is not denied. However, only one town has so far concluded investigations of sufficient authoritative scope to indicate that phosphates could be processed at that point at the lowest possible cost in the nation. That town is Green River, Wyoming.

Prior Investigations

In the past 10-year period both private and public research agencies have been continuously conducting exhaustive investigations on the mineral fertilizer resources of the Green River locality. The cost of these investigations have totalled more than $200,000 to date. The findings of these investigations have been published in Government bulletins as well as in leading chemical journals. These publications provide the answers to a thousand or more questions yet unanswered for other localities in Wyoming and elsewhere. No public or private agency can longer afford to ignore these widely heralded findings of record if it is seeking a location for a phosphate works at any point within the Inter-Mountain states.

This office is headquarters for all industrial reports published to date on the chemical fertilizer resources of the Green River district. Photostatic copies of at least seven of the more important reports published on the local community will accompany the original copy of this report.

Map - Publicity Sheet

A map of Green River appears as the following page. The double-page insert following it is a publicity sheet recently put out by the Community Club of that city. A glance at these exhibits

GREEN RIVER WYOMING

PROGRESSIVE AGGRESSIVE POSSESSIVE

Finest and most consistent water supply in Wyoming with cheap commercial and industrial water rate.

Wealth of power and heat energy through electricity, coal and gas. Natural gas from adjacent fields; 15 miles from one of the largest coal fields in the world.

Low tax rate—one of smallest levies in Rocky Mountain region.

Sound banking houses.

Large fire-proof brick school structures; high school equipped with one of the largest and finest gymnasiums in the West.

Good restaurants, hotels, garages, filling stations, cabin camps, etc.

Four churches.

County Seat of Sweetwater County with county building and landscaping occupying city block.

On Lincoln Highway, paved route traversing southern Wyoming; connecting link with Yellowstone Park highway and summer playground area of lakes, streams and the world's grandest scenic wonder spot.

Paved streets; miles of concrete walks and gutters; splendid street lighting; excellent sewerage and water systems; adequate fire protection; underpass vehicle crossing and pedestrian overpass spanning twenty one tracks of Union Pacific and Oregon Short Line railroads; recreation center in beautiful Island Park surrounded by Green river; municipal swimming pool and aviation field.

Most beautiful city in Wyoming for trees and lawns.

Important division point for Union Pacific and Oregon Short Line railroads; Western Division headquarters for Union Pacific; mammoth depot and office structure; Union Pacific dining room, hotel, club house, beautiful community social hall, large round house, machine shops, car repair department and many other buildings including beautiful home for Superintendent and private dwellings for other officials.

Approximately 600 Steady Railroad Employees Aggregating Monthly Payroll of $85,000

Seasonal Rail Employment and Crew Work Out of City Swells Total Several Thousands Yearly.

Large stockyards and principal feeding point for stock in transit.

Brewery, County Carnegie Library, beautiful Masonic Temple.

Unlimited industrial possibilities with cheap power, transportation facilities, cheap water and taxes, attractive and inexpensive building sites with wide opportunties for expansion, in the heart of one of the richest mineral deposits in the world.

Sand-gravel pit, shipping hundreds of carloads yearly.

GREEN RIVER'S BEAUTIFUL MASONIC TEMPLE FULLY LANDSCAPED

IN SUMMER THIS VIEW, AS ALL OTHER POINTS IN THE CITY, IS MOST ATTRACTIVE WITH A WEALTH OF TREES, LAWNS AND SHRUBBERY

Green River Wyoming

- **Rich In Opportunity**
- **Unequalled Transportation Facilities For Industrial Marketing**
- **Strategic Location**
- **Picturesque and Historical**
- **Unlimited Expansion Possibilities**
- **Healthful Climate**

ADDRESS COMMUNICATIONS TO SECRETARY

GREEN RIVER COMMUNITY CLUB

OR

TOWN CLERK

GREEN RIVER, WYOMING

A GRAPHIC AND ILLUSTRATED PAMPHLET ISSUED BY GREEN RIVER COMMUNITY CLUB AND TOWN OF GREEN RIVER

strongly suggests that no town of 3,000 people in the West is more "Progressive - Aggressive - Possessive" than Green River, Wyoming.

Natural Resources Within Corporate Limits

The original inserts were not prepared with the view of attracting any specific industry to Green River. The vicinity is a treasure house of the minerals and collateral resources that enter into the manufacture of fertilizer chemicals. At this point some of the natural resources that are located inside of the city limits will be considered.

After studying the map it was concluded that the location best adapted for operation of an electro-thermal phosphate works is the large river bench flat that is traversed by the southeastern boundary lines of the city. Only the industrial potentials of that particular section will be surveyed. To list the specific resources of entire city area would cause unnecessary confusion.

Water Supply

An inspection of the map discloses that the selected site is nearly surrounded by waterways and numerous railway spurs.

On the southern edge the area is bordered by Green River, the stream from which the city takes its name. The airplane view of city on the publicity sheet shows this magnificent perpetually glacier-fed stream in the foreground. The tree-covered scenery is City Island Park of approximately the altitude and contour of the larger flat suggested for a chemical site. The Narrowest point of the stream channel inside of corporate limits is the section spanned by the railroad bridge. At that location the turbulent river course is 575 feet wide.

The cited photo provides a view of the finest and most consistent water supply available in Wyoming. The flow is inexhaustible. No use looking for better quality and volume. There isn't any in the four western states that compose the Inter-Mountain phosphate province.

At Wilson Dam water supply only amounts to 0.8% of the cost of the TVA finished product. No reason why this cost should be higher in the western field any day of the year if proposed plant is located on the correct river frontage.

A new processing plant location might demand two types of water supply. The area suggested at Green River is quite capable of supplying two different varieties on the spot.

Silica Gravel

At Wilson Dam silica gravel is more expensive than the water supply factor. There it takes out 1½ cents from the phosphate dollar.

To provide this commodity at rock-bottom cost a new works should have an old established silica gravel operation within a stone throw of the furnace hopper. Such works now occupies a section of the river frontage on the selected industrial site.

Operation of the Green River Gravel Company's pits has long been one of the major industries of the city. These plants are equipped with latest crushing, screening and loading machinery all electrically operated. Such works are quite capable of turning out silica gravel fluxing requirements of any specified dimension at short notice. These works are the largest of their kind in the West. Markets for their superior products widen continually.

Some engineers frequently assume that commodities as lowly as silica gravel are available in every community. Such general observations may apply in some localities, but it may pay to investigate local resources of towns now seeking the site for a phosphate plant. Some locations might be compelled to purchase their gravel supply FOB, Green River. At any rate sizable volumes of current output are now being exported to points in other states of the western phosphate fields.

Sodium Carbonate

The "possessive" city of Green River is located in a region of variegated chemical deposits. About 30 years ago over 1,000 tons of a very pure variety of sodium carbonate were crystallized on the suggested industrial site. This spot is underlain at shallow depths by brine bearing waters containing 9.29% of sodium carbonate, 2.21% of salt and but little other solubles. The producing strata lie from 75 to 190 feet below the surface. A geologist of the Union Pacific railway reports a vast supply of brine available at this point. Most of it will likely be consumed in the extraction of potash from Wyo-

mingite by the patented Pike process.

Extensive deposits of sodium carbonate are seldom reported this side of Africa. At Green River a natural deposit is generally regarded as a fundamental affilliate for the organization of a modernized, fully self-sustaining, chemical industry. In point of value sodium carbonate is still the second most important manufactured chemical. To make the natural commodity available on the spot the next phosphate reduction works should be built directly over an established soda well.

At Wilsom Dam considerable volumes of sodium carbonate appear to be consumed in the conversion of refractory "gunk" to the soluble form. At the specific Green River site the cost of this valuable fluxing agent could well nigh be ignored. And why build an additional processing plant at any point unless cheaper phosphates can be assured to the customers beforehand?

Natural Gas

The gasline mains from the Baxter Basin fields to Salt Lake City pass the selected industrial site. Baxter Basin lies 15 miles east of Green River. It is the largest and cheapest gas producing reservoir so far discovered within the entire Rocky Mountain petroliferous province. It is probable that the local gas supply will prove more useful for the manufacture of potassic and nitrogenous compounds at the Green River site. Nevertheless, this high power fuel possesses some attractions for the reduction of ordinary phosphate rock. In calorific value the local fuel is worth twice as much as the best manufactured gases generally sold in the larger cities.

For heating and reducing agents the local county can also supply both solid and liquid fuels. But for instant heat generation no agent is more efficient or convenient than natural gas. A ton of the local material rates approximately 50,000,000 b.t.u.s against 26,000,000 for local coals and ordinary cokes. It is unfortunate that double-power fuels and high-grade phosphate rocks do not more frequently appear together at prospective hydro-sites. Seemingly, such assemblages may only be encountered in the Wyoming Wilderness. As a

result, no technological literature is yet available for citation as to the cost of final products of manufacture. Apparently, room also "remains for enormous technical improvement in the manufacture of phosphate plant food" at the Green River site, previously designated.

Again the question of fuel transportation ought to be considered by all towns applying for a location of a new-style electrothermal reduction plant. So far no genius has devised a method to ship the thermal energy contained in a ton of coal as cheap as its equivalency is conveyed in high pressure pipelines in the form of natural gas for any given distances selected. Recently, a company geologist made some thermal calculations. At 13½ cents per 1,000 cubic feet the local gas was equal to coal at $1.70 per ton in Salt Lake City. Better comparables should be available for Green River, for the suggested industrial site is 14 times closer to the producing fields than the pipeline terminal in Salt Lake City.

By this time gas is exported from Wyoming to at least two other states in the western phosphate province. Field prices do not prevail in those terminal territories.

Sulphuric Acid

Gas from the local fields contains an exceptionally high content of hydrogen sulphide. Its removal provides a source for sulphuric acid, but not of adequate volumes for the operation of old-style processing plants.

Some patentees claim that sulphur dioxide exercises a beneficial influence on the local phosphate rock at elevated temperatures. For direct burning in the furnace, special pipeline construction from the fields to the Green River site would doubtlessly be required.

Other sources for big-scale production of sulphuric acid are available in the community. Their intrinsic merits remain to be disclosed by future investigation and experimentation. At this time the copper smelters near Salt Lake City are quite able to provide for all H_2SO_4 requirements of the region.

CHAPTER X

TRANSPORTATION

Railways - Airways - Rock Springs -
Main Street of America

Railways

The City of Green River is one of the big railway centers in the entire West. In the course of a single year over one-half million cars are cleared from that point. As indicated on the preceding map, the railroad yards of the city occupy some 40 miles of tracks.

As noted on the publicity circular, Green River is one of the main division points on the Union Pacific Railway system. It is also the terminus of the Oregon Short Line. The motto of the Union Pacific is --"Serves All The West." At short distances west of Green River, branch lines lead off from the tracks of the first and largest of the Transcontinental systems to all major cities on the Pacific slope from Los Angeles to Seattle. All of this traffic must daily pour through the funnel at Green River, the last westward city served by all trains of the Union Pacific.

A map of the Union Pacific is inserted in the following chapter. A glance will disclose the manner in which the main tracks of the system branch out like the leaves of a fan near the Green River focal point in order to cover all seaports on the Pacific Coast. In turn, multitudinous secondary lines lead off from the main feeder systems.

Serving all of the West, the Union Pacific ought to be the only road that reaches all phosphate areas of the four Inter-Mountain states. Aside from some minor acreages that lie north of the Butte, Montana, terminal, the slogan of the Union Pacific substantially applies to all remaining phosphate areas. For all practical purposes the Montana deposits may be dismissed from the present picture. Twenty-five miles beyond Butte is the large acid plant of the Anaconda Copper subsidiary. Phosphate rock from that locality also supplies an even larger old-style plant situated in British Columbia. At this time no

private or public agency will likely build an additional plant within the highly competitive Montana territory mentioned.

On the Union Pacific system Green River is the only point that has a through and direct line to all phosphate deposits of the Inter-Mountain province aside from the minor acreages lying north of Butte, Montana. It would seem immaterial from what district the rock would originate. It could be shipped to Green River without any back-hauls whatsoever. If rock from all states is to be reduced, it would be cheapest in the long run to send it direct to the strategically located, focal point at Green River.

Too much space has hereinbefore been devoted to the defense of the Western phosphate fields from geographical criticism. It is true that Green River is located 1,302 miles west of Chicago. That distance is not as long as it used to be. A train leaving Chicago at 6:15 in the evening arrives at Green River at 1:58 the next afternoon. Until quite recently, both Green River and New York were about equally remote from Chicago insofar as intervening hours of travel were concerned.

At Green River, the largest and fastest stream-line trains in the world now stop six times a week in each direction. That ultra-modern service is not duplicated at any point west of Green River. In Salt Lake City, the metropolis of the Inter-Mountain states, similar stream-line service is available only once every third day. In other towns known to be seeking a Federal phosphate plant, stream-liners stop once a week or else not at all. Merely to reach such out-moded and more remote localities, the busy technologist or executive would use-lessly waste 24 hours or more of his travel time.

As previously inferred, the great bulk of the western phosphate deposits are tributary to the three feeder lines of the Union Pacific that lie west of Green River. Over such roads the traffic densities can average but 33% of the main-line total. Freight and old-style passenger service over those roads must also agree with the frequency ratios previously described for the stream-line trains, but more important factors favor a plant-site location on the main-line which is double-tracked throughout Wyoming.

After all, travel speeds on the new million-dollar stream-

liners are only 50% higher than the average for regular passenger trains. Far more spectacular advances have been made in the freight service. In recent years velocities of the freight trains on the main line have increased nearer 200%. Freight trains of a hundred cars now travel over the Green River district 119 miles before making the first stop. Only one road in the U.S.A. maintains a faster freight service. The second place position of the Union Pacific is not due to lack of modern rolling stock. The route of the faster road is over the prairies in contrast to the Rocky Mountain terrain traversed by the first and still largest Trans-Continental system. Unfortunately, this speed service is only in effect from Green River to points eastward. On single track feeder lines such high vebcities cannot be maintained without encountering frequent interruptions and serious delays.

Airways

So far through, non-change plane service from either New York or Chicago terminals has been available at only two points in the Inter-Mountain phosphate area. They are Green River and Salt Lake City. Such travel is only a matter of hours. Planes reach other points in these districts, but the service is of the branch-line order. As such, the lay-overs in the local terminals are likely to consume more time than the hours required to leave New York.

Of course, far more planes stop at Salt Lake City than at the airport that serves both Rock Springs and Green River. Rock Springs is 15 miles east of Green River. From both of these points the dual airport can be reached over an unrestricted speed pavement in less minutes than it usually requires for spproaching the terminals of the larger metropolitan cities.

Rock Springs

A word here about Rock Springs. Its population is 9,000 plus. In territory contiguous thereto, 8,000 additional people reside. Rock Springs is one of the largest coal mining communities of the Nation. No point west of the Mississippi River surpasses its annual production. The western phosphate states already supply a sizable market for this fuel output. Rock Springs is also located on the biggest

natural gas field in the Rocky Mountain area. It is the general outfitting point for several other oil and gas fields. In time, Rock Springs will occupy a prominent site on the Green River map. In view of the collateral resources mentioned, these two nearby towns should already be visualized in the light of a single industrial unit.

Main Street of America

From the days of the Pony Express to the arrival of the airways every form of traffic selected the Green River route for their first Trans-Continental lines. All of the pioneer Coast-to-Coast highways, telegraph and telephone systems, likewise, traverse ~~through~~ the leading streets of the city. Services over these central arterial lines greatly surpass the facilities provided by supplementary routes more recently established.

The Lincoln Highway that goes through the city is widely known as the Main Street of America. No subsequent coast-to-coast road handles so heavy a load of automobile traffic. Apparently, the maximum density factor is retained at points as far west as Green River. A score or more buses daily pass through the city. Those westward bound are placarded Los Angeles, Seattle and to intervening cities on the Pacific Coast.

All will agree that lack of quality or shortage of tonnages are not the basic factors that have long delayed development of the western phosphate lands. Big economists would keep these huge deposits in their present state of dormancy until better transportation services are provided for the primitive hinterland in which they are located. Such forms of disparagement greatly agitate the dander of local residents. Right now members of the Green River Community Club rate their local travel facilities as very much metropolitan in scope. In fact, the membership openly challenges any city within the Inter-Mountain phosphate province to duplicate the grade, modernity and completeness of the transportation service already established at Green River, Wyoming.

In the concluding section of this report ~~existing~~ transportation ~~development~~ at Green River City will be expanded 100%.

CHAPTER XI

MARKETS

Local Markets - Sugar Beet Industry - How Phosphates Came To Wheatland, Wyoming - Beet Production By States - Sugar Refinery Map - The 532 Miles

Transportation of a metropolitan order is not sufficient by itself for the location of a new-style phosphate plant. To insure successful operation of the venture, only a few cents per ton should be allowed for transportation of all materials that make up the furnace charges. It is also important for the finished products of the plant to enter into extensive marketing areas at half the freight costs in effect from nearest competitive points. For reaching into either local or national marketing outlets, no location within the entire Inter-Mountain phosphate province possesses the coverage potentials of the site at Green River, Wyoming.

Local Markets

The Sugar Beet Industry

The Rocky Mountain area surpasses the balance of the Nation in only one form of high grade agricultural activity. It is the raising of sugar beets. This industry thrives best under the huge and costly irrigation projects constructed by the Government during the past 35-year period in all four of the Inter-Mountain phosphate states as well as in the three states that form the eastern boundary of the province aforesaid. Its maximum degree of development is near the geographic point that forms the southeast boundary corner of Wyoming. So far as known, no other type of industry has yet urged the use of phosphate for this section of the U.S.A.

How Phosphates Came to Wheatland, Wyoming

The following page is a photostat of portions of a booklet circulated by the Great Western Sugar Company several years ago. It shows a photograph of the "Discovery Field" in which phosphate deficiencies of Rocky Mountains soils were demonstrated for the first time. The original discovery was made by the accidental burning of straw-stacks in a beet field at Wheatland, Wyoming, some 12 years ago.

Shortage of phosphates in that particular field seems to have been corroborated by the following experiments:

> In subsequent careful field trials, the yields of beets was increased from 12 tons to 16 tons or $28 per acre, when beets bring $7 per ton. The superphosphate cost $3 per acre.

The concluding paragraph of insert tells how beet yields were increased 25% in the Wheatland district after 85% of the entire area (7346 acres) was phosphated in ensuing years. Apparently, the application of phosphates is already a profitable venture on some of the newer soils in the Rocky Mountain area.

The Great Western is the largest refining company in this area. Since its organization, about 1905, it has paid out one-half billion dollars to growers for their beets. Since its phosphate program was started in 1930 or before, it has made thousands of free tests for mineral deficiencies in soils tributary to its various refinery sites. Incidentally, 19 of its 22 refineries are in Colorado and Nebraska, two non-producing phosphate states that bound Wyoming on the south and east. By this time, considerable information has accumulated on phosphate deficiencies in these older cultivated soils of the West. If these nationally famous agricultural areas are to be supplied with phosphates at the lowest possible cost, it would be necessary to select a site for the processing plant at some convenient location in Wyoming.

State Production Tables

From year to year the U. S. Department of Agriculture publishes the statistics for sugar beet production in the U.S.A. In the following table productions of all seven states in the Rocky Mountain province appear in ranking order for the year of 1936.

Rocky Mountain District

State	Acres Harvested	Production Tons
Colorado	171,000	2,234,000
Nebraska	68,000	782,000
Montana	60,000	654,000
Idaho	52,000	619,000
Wyoming	44,000	486,000
Utah	36,000	500,000
*South Dakota	12,000	145,000
Totals	443,000	5,400,000

*Figures estimated as Dept. of Agriculture does not segregate productions for states having only one refinery.

The foregoing totals account for more than 59% of the na-

tional sugar beet production for 1936.

Analyses of foregoing acreages indicate that over half of the Rocky Mountain beet industry is in Colorado and Nebraska. Unfortunately, neither one of these two big producers contain phosphate deposits. If Wyoming and South Dakota are included in foregoing total, it is found that 70% of the industry is located in the eastern division.

The third producer is Montana. That state is already supplied with a phosphate processing plant of more than ample capacity for local requirements.

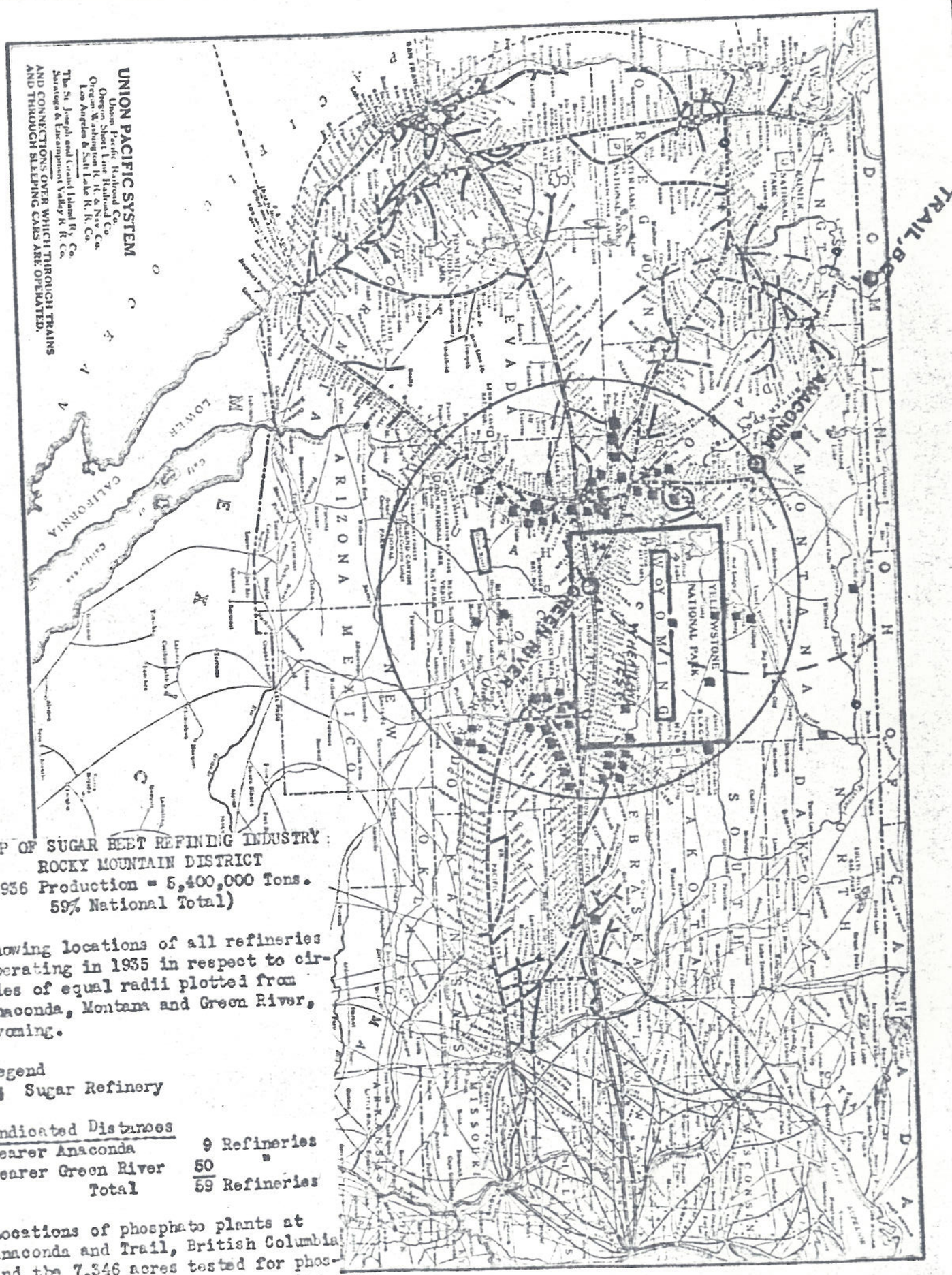
Idaho and Utah remain. Their total acreage constitutes almost 20% of the entire Rocky Mountain beet province. Incidentally, Wyoming's 44,000 acres is exactly one half of the Idaho-Utah total beet acreage. If location of proposed phosphate plant could be decided by beet-culture showings, the individual merits of each one of these states would seem to be about equal. Should a site be chosen at Green River, Wyoming, all of Utah's acreage and about 85% of Idaho's beet lands would enjoy lower freight rates than the charges now in effect from the Montana source of supply for processed phosphates.

Map

To better portray the location of the Rocky Mountain beet industry, a map is inserted on the following page that shows the locations of all refineries operating therein in 1935. The map also shows the sites of the two processing plants now operating at Anaconda, Montana, and Trail, British Columbia. The original Wheatland testing district, an area of unmistakeable phosphate deficiency also appears on this chart.

The City of Green River occupies a central position on this map. Using the airline distance from Green River to Anaconda as a radius, two circles are inscribed from each extremity of the base-line, aforesaid. These circles indicate that no less than nine of the 59 sugar refineries of the Rocky Mountain beet province lie closer to Anaconda. The remaining 50 appear considerably nearer to the Green River central focal point.

The accuracy of the map is not guaranteed. It seems that all railroad maps use some degree of distortion. Nevertheless, a railroad



MAP OF SUGAR BEET REFINING INDUSTRY
ROCKY MOUNTAIN DISTRICT
(1936 Production = 5,400,000 Tons.
59% National Total)

Showing locations of all refineries operating in 1935 in respect to circles of equal radii plotted from Anaconda, Montana and Green River, Wyoming.

Legend
■ Sugar Refinery

Indicated Distances	
Nearer Anaconda	9 Refineries
Nearer Green River	50 "
Total	59 Refineries

Locations of phosphate plants at Anaconda and Trail, British Columbia and the 7,346 acres tested for phosphates at Wheatland, Wyoming, also

map must be submitted. If a Government processing plant locates in the West, it will likely be built on the Union Pacific. The road that serves all of the West offers the only logical locations for a site in Wyoming. In Idaho and Utah about 100% of all the phosphate rock as well as all established sugar refineries seem to be located on that system. For showing available transportation service, a railroad map had to be selected.

In the main, the submitted map merely substantiates conclusions already filed under the production table for the several ranking states of the Rocky Mountain area.

Using one crop as a state agricultural index is also open to criticism. Out here sugar beets seem to excel in the consumption of contained minerals from the soil. The preceding production table indicates an average production of over 12 tons to the acre (worth $84 per acre) for the seven producing states. Few national crops yield that volume of revenue in any state. In agricultural endeavors these western states seem to surpass the balance of the Nation in the production of sugar beets alone. Until a few years ago the Rocky Mountain district produced 72% of the Nation's sugar beet supply. Its output last year was less than 60%. It may not be too late for chemistry to salvage the prestige formerly held by this region in the national sugar beet industry.

A prospective manufacturer of processed phosphates has other things to consider. Thus far only the beet industry has conducted an organized campaign for the use of phosphates in this area. Such pioneer missionary labors are entitled to first consideration.

The 532 Miles

The single phosphate processing plant thus far operating in the western field is located at Anaconda, Montana. That point lies near the extreme northwestern tip of the Inter-Mountain phosphate fields. At the other end of the axis is Green River, Wyoming. Geographical reasoning would strongly favor a second plant at the point of maximum distance.

The railway distance between these two points is 532 miles. The first 507 miles is over the Union Pacific route. That separation is appreciable even in a country as broad as the United States. For

answering the geographical criticism repeatedly cited in earlier pages, no site could possibly surpass Green River for the location of a new-method reduction works.

From Green River, 532 miles will touch a point in Kansas, often called the Breadbasket of the Nation. To reach the Mississippi River via railway, all the way, only 632 miles of additional travel would be required. The latter point lies well within the marketing territory of the Tennessee plants, at least until phosphate rocks are reduced at record-breaking low costs in Wyoming.

In addition to the local market feature, cheap rock and low-cost acid were the two basic factors in deciding the locations for new phosphate works as late as 10 years ago. No acid is used in the latest processes of the TVA. The factor of market outlets is still of primary importance. Before one of these new method plants is built in the Rocky Mountain field, by either public or private interests, a thorogoing study should be concluded of all sites able to ship finished products into logical marketing outlets at half the transportation charges now in effect from nearest competitive points. At this preliminary date the maximum area of both local and national marketing territory appears to lie tributary to a prospective site located in Wyoming.

CHAPTER XII

LOCAL HYDROELECTRIC RESOURCES

Seminoe Dam - Output Sold Before Completion - Supplemental Report

Wyoming has only one major hydro-electric project. It is the Seminoe Dam that is located on the North Platte River, 40 miles northeast of Rawlins. This project will be completed by the U. S. Reclamation Service this coming December at a cost of $10,000,000. Its capacity is rated at 45,000 horse power. To reach Green River, a power extension 120 miles in length would have to be constructed from Rawlins.

Output Sold Before Completion

A recent article in a popular magazine stated that the com-

pletion of the Seminoe Dam would generate a power surplus of 134% above the existing demands of prospective marketing outlets. Acting on this information, a call was made at the Denver offices of the Reclamation Service on June 13, 1938, with the view of ascertaining the feasibility of transmitting all surplus capacity of the project to Green River, Wyoming. An attractive price for this energy was anticipated. However, the Chief Hydraulic Engineer of the Service advised that all of the firm power was already sold, and all that remained for Green River was 30,000 kilowatt ~~hours~~ of dump power available four months of the year at two mills per kilowatt hour. A power supply of that brief duration would not justify the construction of a costly phosphate plant at any point in the United States.

In a report published six years ago, the writer suggested that a reasonable share of the firm power output of the then proposed dam be utilized for the "electro-thermal treatment" of the high-grade phosphate rocks occuring in the Green River locality. Apparently, no one has since requested the Reclamation Service to construct requisite powerline facilities in the direction of the phosphate deposits. As a result, contracts are now let to convey the firm power output of the Seminoe Dam to distant municipalities in Colorado and Nebraska. It would have been far less costly to carry the power to Green River. The latter point is 25% nearer the hydro-project than the terminals selected in the outside states.

The operations of the fertilizer division of the TVA are wholly of an electrochemical or electrometallurgical order. If the Authority builds a reduction plant in the West, it is certain that ample supplies of low-cost hydropower will be arranged beforehand for the specific site selected. Just too bad for towns that cannot meet this basic requirement. They simply do not belong in the electrochemical picture of the TVA setup.

A growing number of chemical engineers were beginning to understand that the Green River country's superb resources in raw chemicals, all fuel types, transportation facilities and widening market prospects would assure a rich industrial future for that region. Plenty of erroneous presumptions were made. To stimulate development,

nearly all agreed that it would be necessary to back up the unique local combination with plenty of power of the most highly perfected form yet known to industry. This type of power will be produced at a nearby site within next twelve months. Instead of going to Green River, it will be routed in an opposite direction to distant points outside the state. Apparently, no civic or scientific bureau of the state has yet filed a protest against the exportation of a commodity so vital for the development of the adjacent Green River area.

For years past local statesmen have vainly endeavored to regain water titles deeded in fee simple to other states 30 or more years ago. In recent months it might have been more profitable to salvage yet unconveyed hydro-resources for big-scale industrial development solely within Wyoming. In this age of air conditioning and other newly developed marketing outlets of magnitude, the demand for power increases at a far more rapid rate than expansion within the irrigation industry. In years to come, former water titles of Wyoming may possess two values. Such documents will likely legalize both reclamation and power expansion at points outside the state.

Supplemental Report

The hydroelectric resources of Wyoming are extremely limited in magnitude. The site at Seminoe Dam represents the first and last of its major water power projects. If the unique combination of chemical and mineral resources of the Green River community are to be reduced, it will be essential to import the requisite energy from an outside point. Some states are not unduly liberal when requested to divide their hydro potentials among less fortunate neighbors. Nevertheless, a diversity of precedents could be pointed out on the never failing readiness of Wyoming to share a princely heritage of natural resources with her sister states.

The selection of a power supply for a great electrochemical enterprise is not casually arranged or quickly achieved. The construction of an extension line 120 miles long would have been a far less formidable task. Such far less costly construction would have permitted the operation of an all-Wyoming process at the Green River site at an early date. Building a hydro project in another state brings in new

obligations. Obviously, citizens of said state would lose little time in seeing that the power output would be chiefly utilized in processing the ore, chemical and fluxing supplies occuring within their own bailiwicks.

Actual sale and exportation of entire firm-power output of a Wyoming hydro project a year before date of completion causes many grave miscalculations to enter into the industrial picture at Green River. This unprecedented situation demands the preparation of a supplementary report. The revised locations and estimates will have to appear as Part II of present report.

REED

PART II

CHAPTER I

FLAMING GORGE HYDROSITE

U. S. Geological Survey Report - Detailed Plans - Compilation Summary of Green River Hydrosites - Profile of Hydro-section on Green River - The Key Site at Flaming Gorge - Subsidiary Power Projects - Cost of Key Project - A Twin Project - Red Canyon Site - Adverse Advertising

The most magnificent chain of low-cost hydrosites yet remaining undeveloped in the U.S.A. appears on the channel of the Green River. All major sites of the local hook-up are described by Ralf R. Wooley in USGS Water Supply Paper No. 618, entitled, "The Green River and Its Utilization," (1930). His description of topmost member of the quintette group nearest to the city of Green River follows:

"Flaming Gorge Power Site

Location - The Flaming Gorge power site (9AK 1) is on the Green River just south of the Wyoming-Utah line. The dam site is in the upper end of Horseshoe Canyon, in the SW.¼ sec. 31, T. 3 N., R. 21 E., Salt Lake base and meridian. (See pl.1.)

Physical characteristics. - Horseshoe Canyon is a narrow gorge with massive sandstone walls, in many places almost vertical. (See pl. 31,A.) In August, 1923, a preliminary permit was issued to the Utah Power & Light Co. by the Federal Power Commission for the development of this site. Under this permit more than 20 drill holes were sunk in Horseshoe Canyon and 10 in Flaming Gorge. Bedrock was found in Flaming Gorge at depths of 40 to 45 feet and in Horseshoe Canyon at depths ranging from 50 feet at the upper end of the canyon to 73 feet at the lower end. As a result of these investigations and studies of cross sections at many places the dam site above indicated was chosen as best suited for the proposed development. At this section the average altitude of low water is 5,839 feet above sea level and a dam with its crest at 6,065 feet would have a crest length of 875 feet. (See pls. 32 and 33.)

In commenting on the geology of Horseshoe Canyon for dams J. B. Reeside, jr., geologist, who accompanied the Green River survey party says:

'For dam sites in Horseshoe Canyon the Weber sandstone affords strong, tight walls and a good foundation under the fill in the stream. The sandstone is a good building material in blocks or broken for concrete. The only limestone in the neighborhood is in the Park City formation and in the Twin Creek formation of Boars Tusk. Probably neither is of a type to be serviceable for manufacture of cement on the ground. The only natural spillway for a dam site in Horseshoe Canyon is the saddle in the NE.¼ sec. 36, T. 3 N., R. 20 E. This is not very good, because the rock of the saddle is the soft, easily eroded shale of the Park City formation. Possibly a spillway could be cut in the inclined top of

the hard basal part of the Park City formation, which lies beneath these soft layers and would not be easily eroded.'

Plans of development. - A gravity-type concrete dam is proposed. Its crest length is 875 feet, at 6,065 feet above sea level. An overflow-type spillway is provided at 6,045 feet. (See pl. 33.) The reservoir formed above the dam will extend up the river for a distance of about 60 miles, and the capacity of the top 50 feet is shown by the following table:

Contour (feet above sea level)	Area (acres)	Total capacity (acre-feet)	Contour (feet above sea level)	Area (acres)	Total capacity (acre-feet)
6,010	25,500	- - - - -	6,040	31,800	854,500
6,020	27,300	264,000	6,050	34,300	1,185,000
6,030	29,500	548,000	6,060	37,200	1,542,500

An earthen dike is proposed across the saddle northwest of the dam. This dike would be built to an altitude of 6,075 feet and be about 1,460 feet long. The details of the dam, power house, and dike are shown on plates 32 and 33. The water is to be passed through intakes in the dam itself to the turbines in the power house on the lower side of the dam. The static head on the plant averages 196 feet and ranges from a maximum of 221 feet to a minimum of 171 feet.

Water supply. - From the stream-flow records of the Green River at Green River, Wyo.; at Bridgeport, about 44 miles below the power site; and at the power site itself for 1924-25, an estimated regulated flow of 2,620 second-feet is available at this site under present conditions. It is believed that this quantity will never be reduced more than 20 per cent by all future irrigation in the basin above, plus the losses that will result from evaporation from the proposed reservoir.

Power capacity. - With a stream flow of 2,620 second-feet and an average static head of 196 feet the power capacity of the site in roundnumbers is 41,000 horsepower, or 30,750 kilowatts. However, the proposed plan of development as shown on plate 33 contemplates the installation of three 21,000 horsepower turbines, each direct connected to a 15,000 kilowatt generator, and the plant is designed for a maximum hydraulic capacity of 3,900 second-feet.

Rights of way. - Most of the land involved in this project is in public ownership. Only a small amount of agricultural land would be flooded by the reservoir, and this is in private ownership. Part of the county highway between Linwood, Utah, and Green River, Wyo., would need to be relocated, and a new bridge would be required at the crossing over Blacks Fork.

Accessibility. - The project is easily accessible from Green River, Wyo., over a good earth road. The distance is about 65 miles.

Adaptability of plan. - The proposed plan of development at this site will completely regulate the flow of the river at the dam. It is at the "top of the hill," and the regulation is thus available at all the power sites on the river except the few in the upper basin. It fits admirably into a complete and comprehensive plan of development of the stream. It is not an attractive power project if considered by itself, as the estimated cost of its development is approximately $12,000,000, or about $300 per firm horsepower. Its value to other developments below, however, makes it a site of considerable economic importance."

More than Federal agencies have thus far disclosed interest in the hydro-economics of the remarkable site, previously cited. Mention was made of the power permit that the Federal Power Commission issued to the Utah Power and Light Co. for the development of this attractive site some 15 years ago. The foregoing concern operates public utility franchises in Green River as well as in 40 other cities of Wyoming, Utah, Idaho and Colorado. It is a subsidiary of the Electric Power and Light Corporation which in turn is controlled by the Electric Bond and Share Company.

Detailed Plans

For 30 years or more the preceding interests have been conducting surveys of a dozen or more prospective powersites that are all located on Green River. These investigations have been confined to the 387-mile long stretch of wild canyon scenery that intervenes the two railway bridges thus far constructed across Green River at Green River, Wyoming, and at Green River, Utah. Apparently, most of the work was done in cooperation with the USGS on a 50/50 cost basis. So far detailed plans have been published for only the Flaming Gorge dam, the key structure for all future hydro development on the Green River. Some of these plans appear as the next two pages of this report.

The Geological Survey and the utility company also made joint studies of the market situation. They believe that the Salt Lake City and Denver metropolitan areas will have little difficulty in absorbing the entire capacity of the power plant. These long-distance transmission markets are of appreciable magnitudes, but all past investigators completely ignored the unprecedented electrochemical possibilities of the damsite area, itself. Had a detailed engineered survey been made of that exact spot, it is almost certain that a sizeable industrial enterprise would be thriving at that point even by this time. Apparently, the chemical deposits underlying the dam foundations, alone, greatly exceed the raw chemical resources of entire states in which much costly hydro-construction has been under way in the meanwhile.

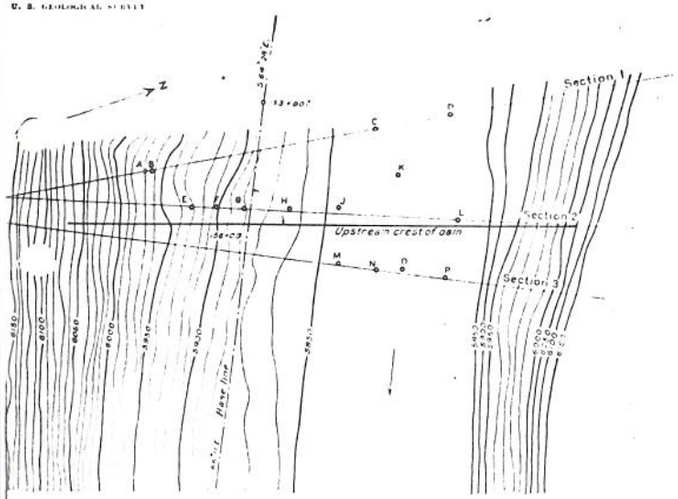
Compilation Summary of Green River Hydrosites
Profile of Hydro-Section on Green River

More powerful hydro-projects could be built along Green River at a lower cost than the investment required to finance the key project

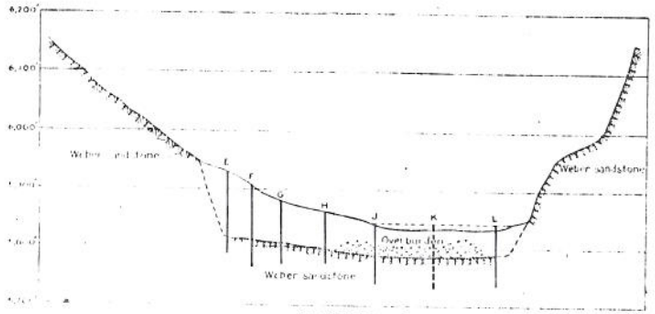
U. S. GEOLOGICAL SURVEY

USGS

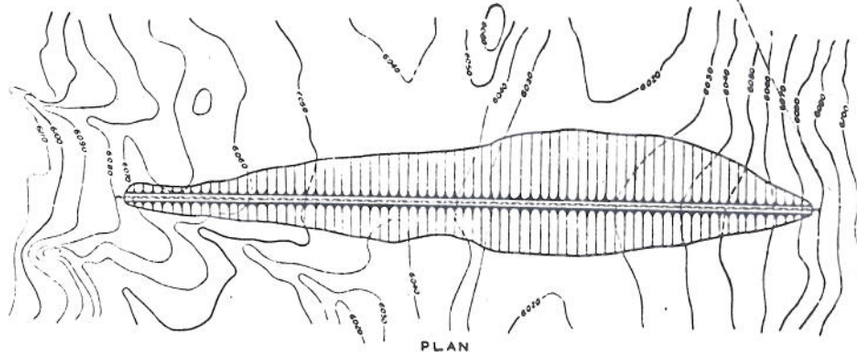
WATER-SUPPLY PAPER 845 PLATE



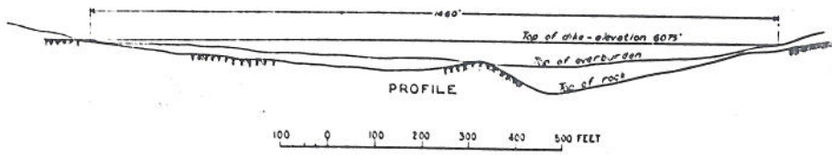
PLAN
showing location of drill holes



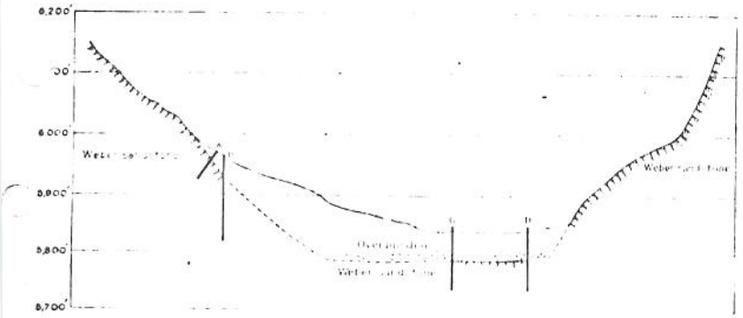
SECTION 2



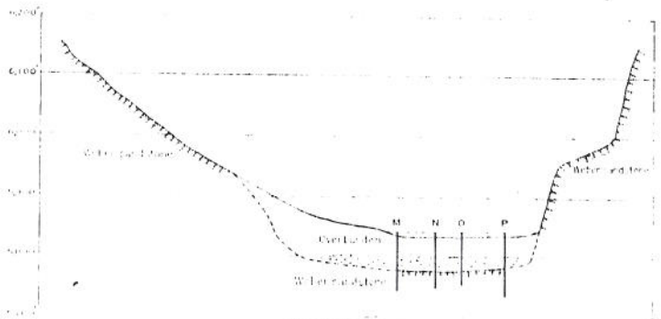
PLAN



EARTH DIKE

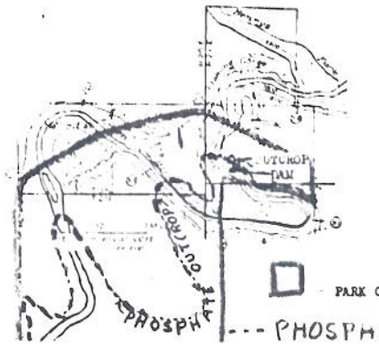


SECTION 1



SECTION 3

MAP AND CROSS-SECTIONS OF DAM SITE AND AUXILIARY DIKE FOR FLAMING GORGE POWER DEVELOPMENT

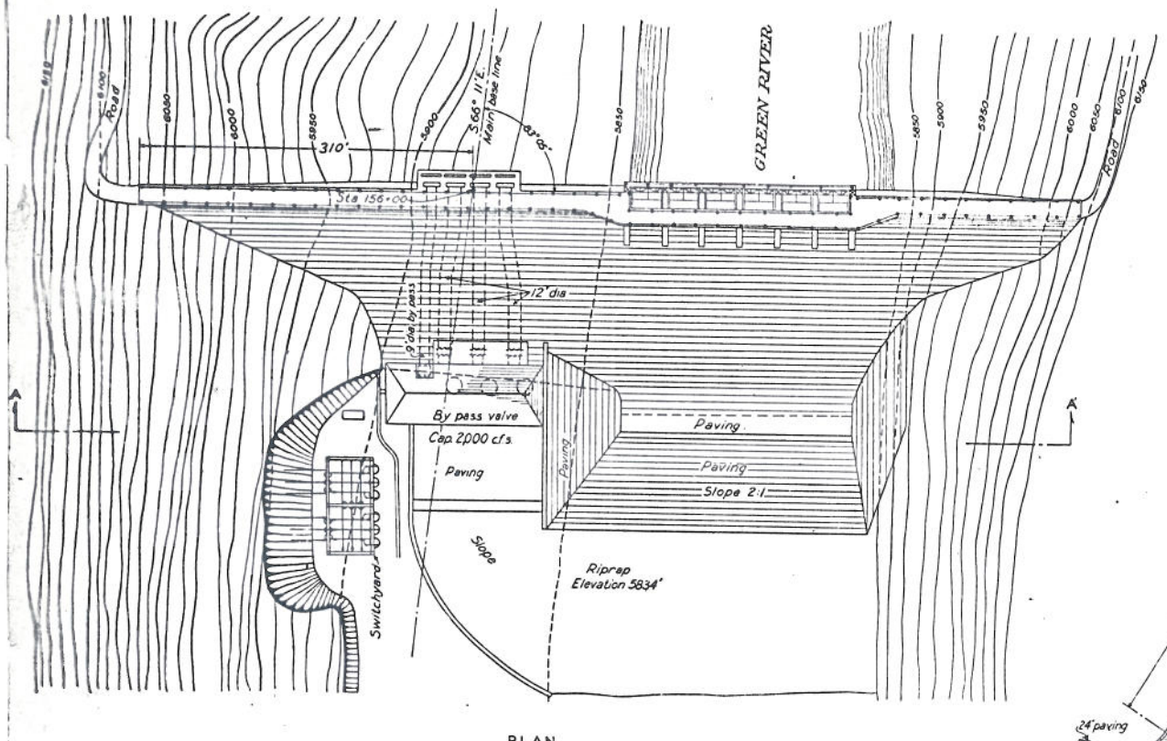


MAP SHOWING
PHOSPHATE OUTCROPS
AT FLAMING GORGE
DAM SITE

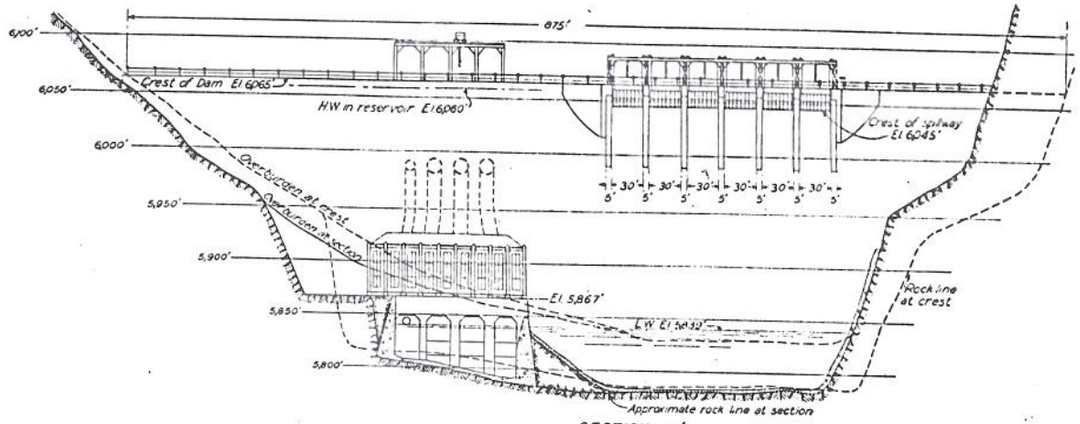
PHOSPHATE — 4'-2" BED
$Ca_3(PO_4)_2$ = 59.92%
Located About
100 yds Above Dam Site

PARK CITY (LIMESTONE) FORMATION

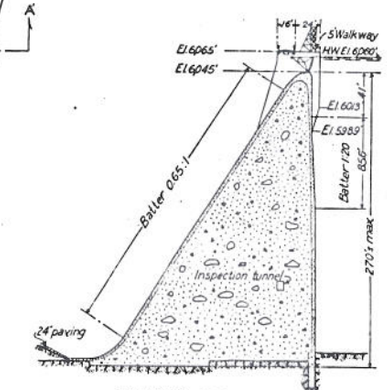
--- PHOSPHATE OUTCROP



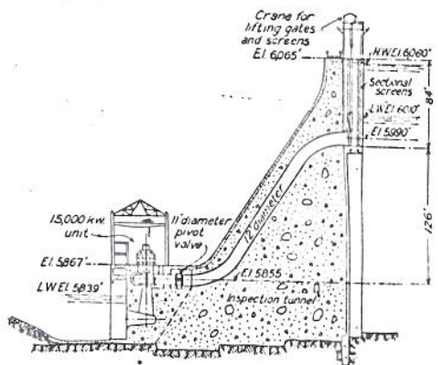
PLAN



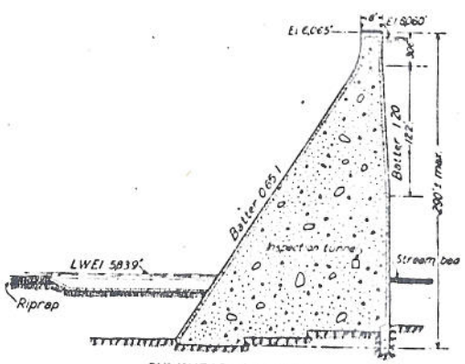
SECTION A-A'



SPILLWAY SECTION



SECTION THROUGH DAM AND POWER HOUSE



BULKHEAD SECTION

50 0 50 100 150 200 250 FEET

DETAILS OF PROPOSED DAM AND POWER HOUSE AT FLAMING GORGE SITE

at Flaming Gorge. The USGS publication also describes the six outstanding sites that lie below Flaming Gorge. These important descriptions are too long for quotation. The best that can be done is to offer a compilation sheet that lists the more significant figures for each project. This summary as well as the River Profile of the Survey occupy the adjoining two pages of this report.

The Key Site at Flaming Gorge - Subsidiary Power Projects

Repeatedly in the USGS publication the Flaming Gorge is graphically referred to as the "basic" or "key" or "Top-Of-The-Hill" site for what is locally considered the finest and cheapest system of interlocking hydrosites yet undeveloped in the U.S.A. A glance at the profile insert suffices to establish its summit position for regulation of the flow over the entire lower-down section of the stream. In time, water released from the Flaming Gorge reservoir with a degree of constancy comparable to Niagara will be reused six times for the generation of firm power at the several sites tabulated on the compilation.

A further glance at relative cross-sectional areas plotted on the profile sheet strongly indicates that the Flaming Gorge pool will occupy the low-gradient plains type of topography. The sites down the hill are all located in narrow vertical canyon sections of the wild and turbulent stream. One of these more scenic sites is superimposed on the profile. Back of all these auxiliary dam locations are stream gradients of a steeply pitching order. Such topography produces reservoir surfaces of an average width around 200 yards. Literally speaking, the contents of such collection basins only amount to a few bucketsful as compared to the huge impoundage hereinbefore quoted for the Flaming Gorge site. A 50-foot downdraw from the Top-of-Hill pool would operate the complete series of subsidiary dams at their maximum head levels every day of the year.

The compilation discloses that three of the proposed powersites lie within 52 miles of Green River, Wyoming. Regardless of this proximity to the Main Street of the Nation, the lower down reaches of the Green traverse some of the wildest and most unexplored scenery yet remaining in the Nation. Aside from the two expeditions of the USGS, the Government publication shows that only six parties successfully navi-

COMPILATION SUMMARY OF HYDRO SITES ON GREEN RIVER

From Green River, Wyoming to Green River, Utah

Top-of-Hill Key Regulation Project of Hydro System

Name	State	Location: Miles Below Green River, Wyo. Airway	Location: Miles Below Green River, Wyo. Waterways	Dam Height Feet	Regulated Flow Second-feet	Horse Power	Reservoir Capacity Acre-feet	Cost	Accessibility
FLAMING GORGE	Wyoming Utah	Airway 41	Waterways 71	226	2,620	41,000/	1,542,500	$12,000,000	On road to Green River, Wyo.

Down-Hill Auxiliary Sites Dependent on Operation of Key Project Above

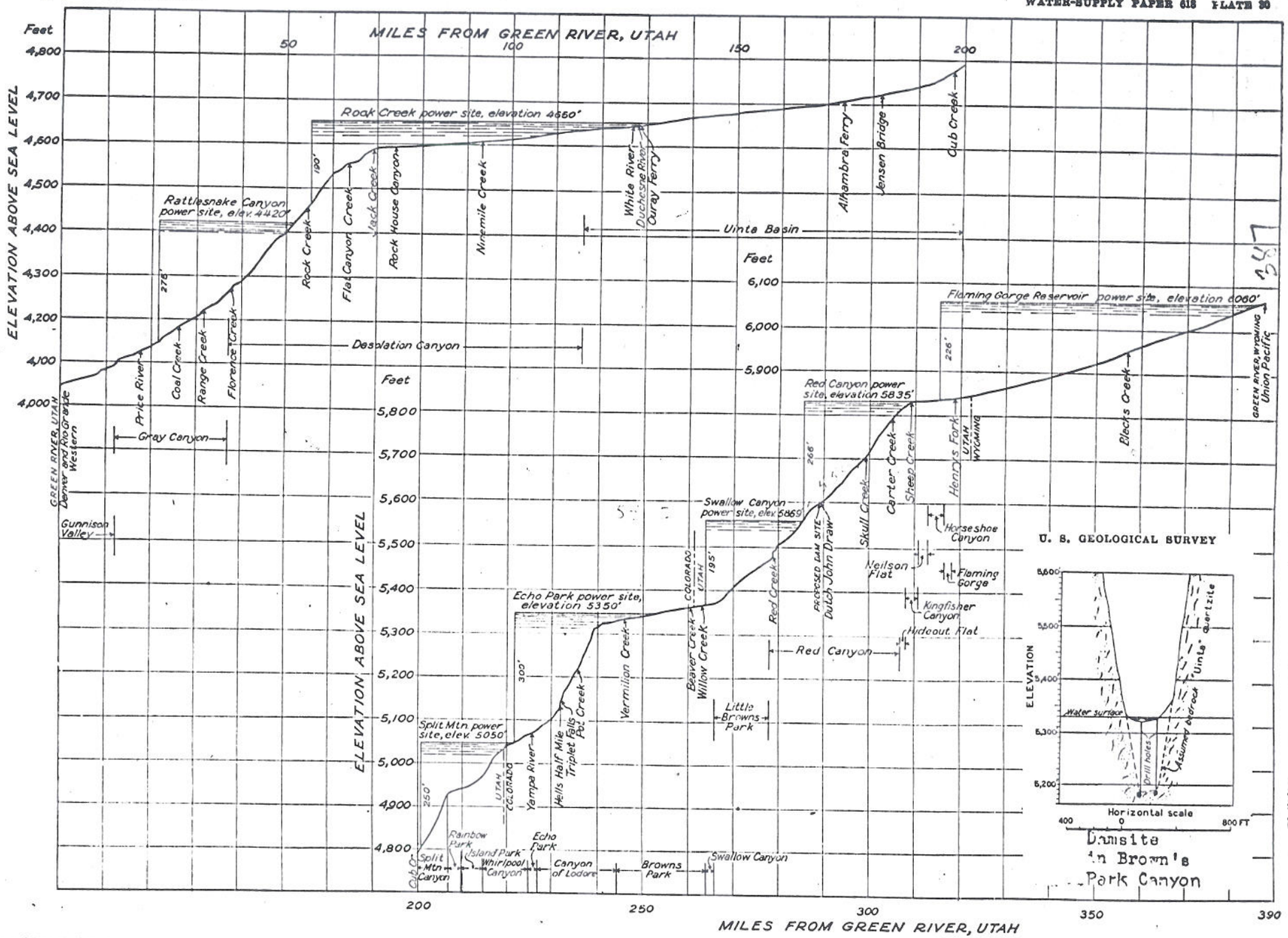
Name	State	Location: Miles Below Green River, Wyo. Airway	Location: Miles Below Green River, Wyo. Waterways	Dam Height Feet	Regulated Flow Second-feet	Horse Power	Reservoir Capacity Acre-feet	Cost	Accesibility
Red Canyon	Utah	43	101	266	2,720	57,900	100,000	Not Estimated	Approachable from Green River, Wyo.
Swallow Canyon	Utah	52	124	195	2,740	34,700		" "	Approachable from Green River, Wyo.
Echo Park	Colorado	73	166	300	4,950	114,800	575,000	" "	Approachable from Green River, Wyo.
Split Mountain	Utah	76	186	250	5,100	91,800		" "	Remotest point from railroads.
Rock Creek	Utah		332	190	7,000	100,000	over 300,000	" "	Only 55 miles from Green River, Utah
Rattlesnake	Utah		365	275	7,000	154,000		" "	Only 22 miles from Green River, Utah
TOTALS		*181	*387	1,702 (ALL DAMS)		594,200			

Total Fall of River from Green River, Wyoming to lowest Damsite 1,914

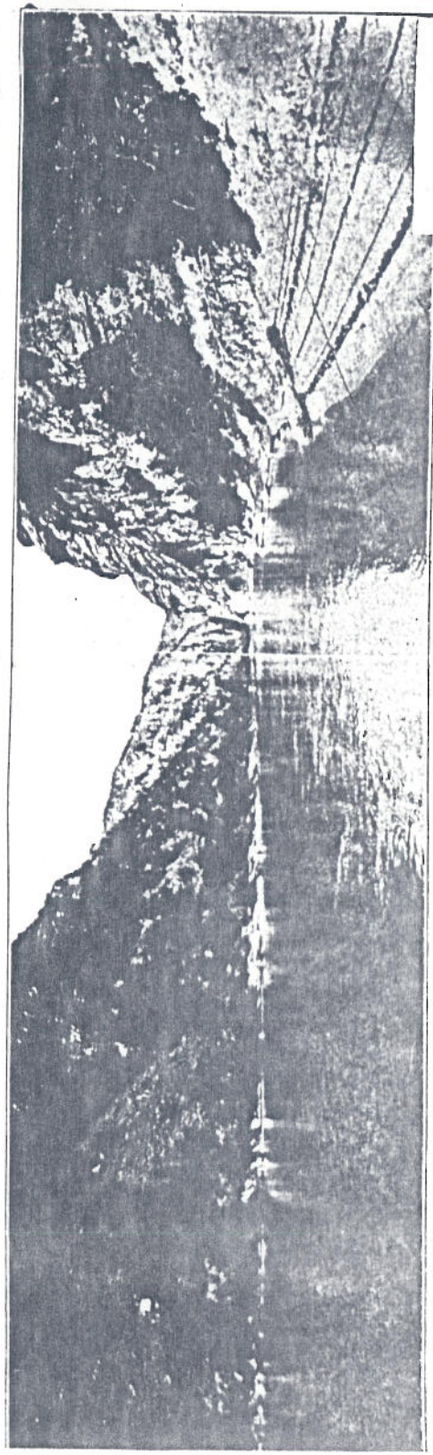
*Distance between Green River, Wyoming and Green River, Utah.

U. S. G. S. Data from Water Supply Paper

No. 618



PROFILE OF GREEN RIVER FROM GREEN RIVER, WYO., TO GREEN RIVER, UTAH, SHOWING SUGGESTED PLAN OF POWER DEVELOPMENT AND ALTERNATE DAM SITES



FLAMING GORGE

VIEW DOWN HORSESHOE CANYON TOWARD DAM SITE DRILLED BY UNITED STATES BUREAU OF RECLAMATION

gated the lower-down sector of the perilous Green within the preceding 106-year period.

Future navigation should prove far less hazardous. From Green River, Wyoming, to the lowest damsite at 22 miles above Green River, Utah, the stream-fall is 1,914 feet. The total height of all seven intervening dams will be 1,702 feet. Such engineering development would metamorphose some present 365 miles of generally impassable cataractal scenery into an elongated stairway system. Seven placid pools arranged in interlocking order with only a single break would serve for the steps of this ladderway. It is hardly surprising that the vital key member of the chain attracted the attention of hydraulic engineers in the employ of big utility concerns as early as 30 years ago.

Cost of Key Project

The prior extract records the cost of the Flaming Gorge project at $12,000,000. The figures for the lower down auxiliary projects do not appear in the cited publication. Detailed plans for these secondary units are not yet available from Federal or private investigational sources.

The USGS estimated the cost of firm power at the Flaming Gorge site, alone, at $300 per horsepower. That figure appears fully 50% higher than the desideratum generally representative for hydrocapacity construction on the part of the Federal Government. The Flaming Gorge unit is, however, a dual power and storage project. In addition to power generation this top member must supply the basic regulated flow for the operation of all six down-hill projects, auxiliary thereto, over the entire Green River system. The major object of Flaming Gorge construction is to provide complete regulation of the stream flow. If only one-half of the construction is charged to that basic or pioneer feature, the cost of power generation directly at the site would not be over $150 per horsepower. The latter appraisement should prove attractive for development at points that offer local markets for hydro energy.

On the compilation summary the firm output at Flaming Gorge is recorded at 41,000 horsepower. The total for the whole stream is 594,000 horsepower. No big utility corporation will likely develop one of the lower-down, exclusively, power-type dams until complete regulation of the Green is perfected at the logical top-of-hill site. As a

matter of equity such concerns ought to be willing to pay for their basic water supply completely controlled at the key reservoir site. On a dam pro-rated basis, ultimate cost of the Flaming Gorge regulation member of the Green hydro-system will likely approach a figure as low as $2,000,000.

A Twin Power Project

The ability of the subsidiary lower-down power sites to absorb the previously suggested system of bookkeeping may be best understood by filing a description on one of them. The first site below Flaming Gorge is the Red Canyon. At that point a dam 266 feet high is proposed. The structure will be 40 feet higher than Flaming Gorge. It should not cost so much to build for the cross-section of the towering canyon walls at that more favorable point is only half the width at Flaming Gorge.

The Flaming Gorge site establishes the height of the Red Canyon dam. On completion, back-waters will extend to the upper barrier. Yet, only 100,000 acre-feet of water can be stored in that 31-mile long sinuous pool. That volume is only 6% of the higher feeder reservoir. It is proposed to operate the lower project at the full dam head every day of the year. Such subservient operations will require a 50-foot drawdown from the higher key pool. In a sense, these twin dams form a single hydro project. Each component member should be equally assessed for its requisite storage consumption. In fact, a glance at the river profile sheet discloses that the top five sites of the Green River chain forms a similar completely connected hydro system. All members of this quintette group must rely on the Flaming Gorge reservoir for the major share of its water supply. No matter how many times the water is reused for salable power generation, each dam of the interlocking system should bear its share of the base storage cost of operation.

Apparently, the construction of these five dams will average around $10,000,000 per unit. Construction of some single dams elsewhere seem to exceed the estimate for entire series of local dams by several times. Construction of these local projects should be conducted on a minimum risk, piece-meal basis. To avoid any possibility of a substantial power surplus in the Green River sphere, only one of

these minor projects should be built at this time. No second unit should be attempted until a market arises for its output beforehand. Apparently, that is the method utilized by the U. S. Reclamation Service in constructing hydro projects in Wyoming. The USRS will complete their Seminoe Dam project next year. Already its entire capacity is sold. Mention was previously made of the inability of the USRS to sell any firm power to Green River from its nearby site at Seminoe Dam. At this time surplus hydro-capacity is not a problem for solution in Wyoming.

The unusually wide degree of flexibility available for the construction and operation of hydro projects along the Green River is best explained in the cited Survey publication. The following description discloses the manner in which the first lower down link of the chain would depend on the operation of the Flaming Gorge key project for the source of its power supply.

"RED CANYON POWER SITE

Location. - The Red Canyon power site (9AK 2) is on the line between secs. 19 and 20, T. 2 N., R. 23 E., Salt Lake base and meridian, at about mile 285¼ of the river survey made in 1922 by the Geological Survey, 7 miles above the mouth of Red Canyon. (See general location on pl. 1.)

Physical characteristics. - At this site the water surface in July, 1922, was 5,569 feet above sea level. The width of the canyon at the water surface was 150 feet, and a dam 266 feet in height above the water would have a crest length of 700 feet. (See fig. 25.)

Plan of development. - A dam with power house built into it similar to the type for the Flaming Gorge project (pl. 33) is suggested for this site. By raising the water surface to 5,835 feet above sea level as a maximum, it would then not interfere with the Flaming Gorge development above. The full head at the dam could be made available at all times by regulating the stream at the Flaming Gorge plant.

Water supply. - Complete regulation of the stream is contemplated at the Flaming Gorge dam. The Red Canyon site is 31 miles farther down the river, and a few important but small streams enter in this stretch. It is believed that there would be sufficient flexibility in the operation of the Flaming Gorge plant along with the Red Canyon plant to obtain a regulated flow of about 2,720 second-feet at this site. This estimated flow is based on stream-flow records on the Green River at Green River, Wyo., and records obtained at the Flaming Gorge site during the investigations under Federal Power Commission preliminary permit. The reservoir formed in the canyon by this dam would have a surface area of about 1,300 acres, and with an average depth of 80 feet its capacity would be approximately 100,000 acre-feet.

Power capacity. - With a static head of 266 feet and a stream flow of 2,720 second-feet the power capacity of this site is 57,900 horsepower (43,500 kilowatts). Maxi-

mum use of the streams above this site for irrigation will probably never reduce this capacity more than 15 or 20 per cent.

Right of way. - Nothing but a narrow canyon would be affected by this project. There is no agricultural area involved, and apparently there would be no flowage damage.

Accessibility. - This site is not now readily accessible, and this fact will have an important effect on the economic feasibility of the project. After the Flaming Gorge site is developed and more power is needed this project or one at some other perhaps more feasible section in Red Canyon will then become attractive."

Note that the only objection the hydraulic engineer of the Geological Survey filed against the economic feasibility of this project was its inaccessibility. On compilation insert, airline distances of the Flaming Gorge and Red Canyon sites from Green River are recorded at 41 and 43 miles respectively. That separation differential is inconsequential.

So much progress has been made in the Green River community that it is already safe to regard the 8-year old statement of the Survey in the light of an anachronism. On map insert in next chapter the big Clay Basin gas field will be plotted on the Wyoming-Utah stateline at a point only 8 miles northeast of the Red Canyon damsite. During past 18-month interval thousands of tons of heavy, deep-drilling equipment have been safely transported from the environs of Green River to the point aforesaid. Haulage of such material requires the identical, heavy-duty type of trucks utilized in the construction of giant hydro dams in Wyoming and elsewhere. Already talk is heard on the advisability of constructing a paved roadway in the direction of the newly discovered gas field. Such a pavement may precede the completion of Red Canyon plans by many months.

So far as known, no road has yet been built over the remaining 8-mile sector in Utah. Red Creek, a sluggish stream that is otherwise inconspicuous in Wyoming, bisects the Utah portion of the Clay Basin gas field. It thence flows southward until it finally enters the Green in Ashley Park, about four miles below the Red Canyon site. Over the entire route in Utah only one contour line appears to be intercepted on the USGS Ashley Quadrangle sheet. Road construction over that final parkway sector should no longer serve to jeopardize hydro-economics as meritorious as those described for the Red Canyon site.

New mineral discoveries of the magnitude of Clay Basin do

much towards advancing the feasibility factor of hydrosites lying tributary to the City of Green River. Power consumption is a costly item in the construction of the ordinary project. To build the Seminoe Dam it was necessary to hook-up a gas-fired power station located 110 miles therefrom at Midwest, Wyo. It may be cheaper to lay a 10-mile long gas-main at the outset at Red Canyon. Such facilities would provide spot power for revision of construction estimates in the downward direction. The line would also supply all of the fuel needed to heat the construction camp. Fortunate residents of the new model spotless town would enjoy thermostatic conveniences, made-to-order climate, spectacular scenery and other attractions quite beyond the accessibility limits of the general inhabitant of the great metropolises.

It was originally intended to file a comparison of the total power output of the quintette of hydrosites tributary to Green River against the energy potential at Niagara. Such a task is no longer necessary. Regardless of the meritorious manner in which the Survey revealed the potential value of these tremendous natural resources, all three of the lower down component members of local hook-up were located in virtually inaccessible and yet unexplored regions. But only a week ago a pavement was formally opened for through Coast-to-Coast travel within six miles of the most remote site. Little good would be done in bringing the two remaining units within hailing distance of transportation. Obviously, such sites will not likely attract serious attention until revenue records become available on the operations of the more approachable projects of local hook-up.

Adverse Advertising

Citations of the preceding category do much to retard normal industrial expansion in this locality. They are frequently followed up by an unnecessary flood of damaging advertising. In recent months a series of editorials in the New York Times exposed the economic fallacies of processing phosphate rock at any point within the vast Inter-Mountain province. The editor's observations might have had application in some sections of the West. They did, however, succeed in missing by a full 100% margin every basic economic potential that sharply

demarcates the Green River community from any other spot in the world. Fortunately, the more dogmatic protestations of the editor seemed to be based on nothing more material than an uncanny ability to detect derogatory conclusions appearing in various lists of Federal publications.

Fortunately, the day is past for a member of the technological press to fire a blind broadside against the character, volume or variety of minerals, chemicals, fuels, and other types of primary power producers that hook-up and over-lap one and another in the Southwestern Wyoming sector of the Green River valley.

CHAPTER II

A SELF-CONTAINED ELECTROCHEMICAL BASIN

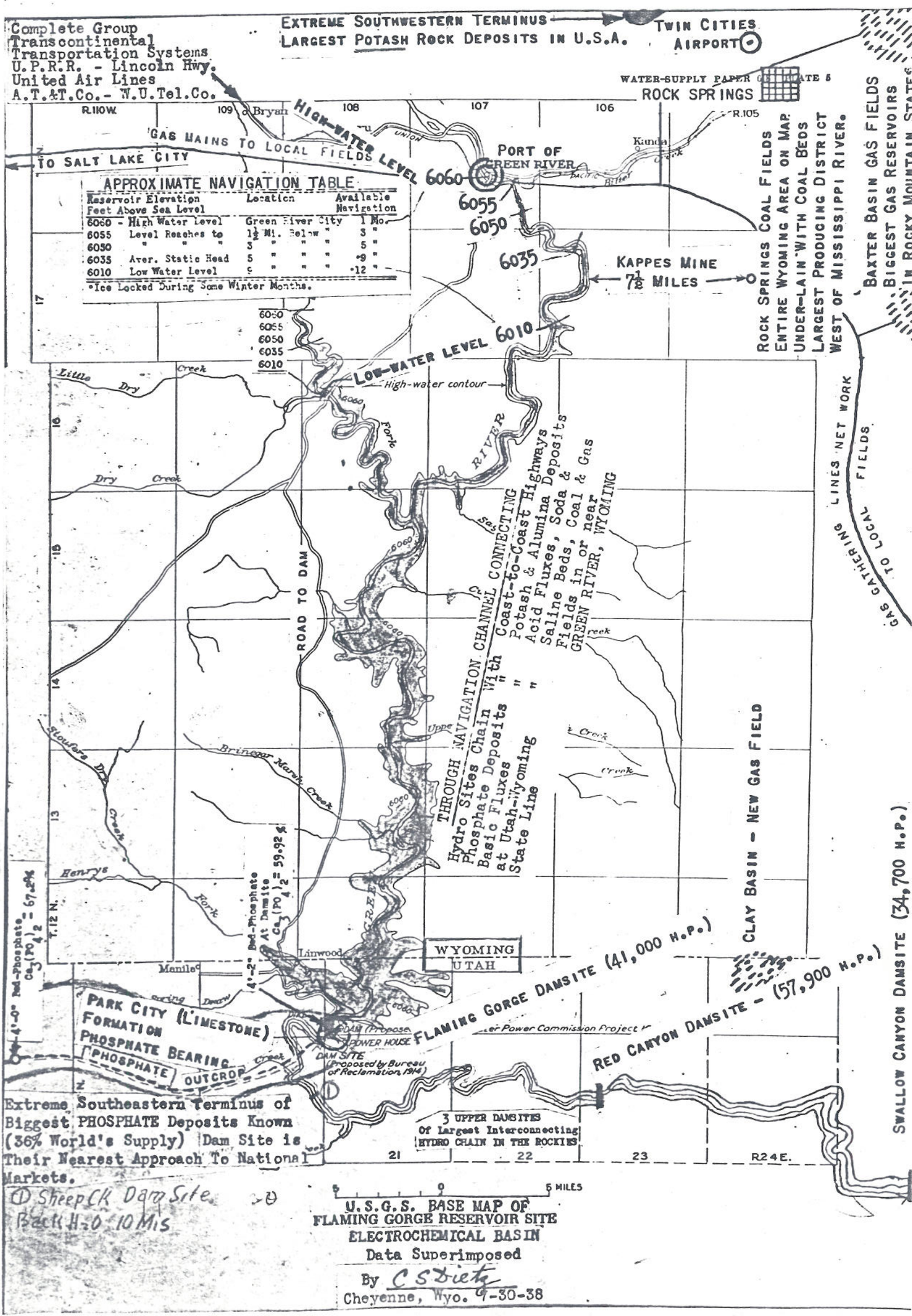
Reservoir Base Map - Major Resources Superimposed on Reservoir Map - Hydro Power - Coal - No Transmission Lines - Natural Gas - Oil - Petroleum Coke - Phosphate & Potash Deposits - Acid & Basic Flux Supplies - TVA Cost Production Table - A Venetian Highway - Valuations - Irrigation vs Hydro Develop - National Recreational Area - Canyon National Monument

The outstanding hydro-electrical basins of the nation are generally barren of noteworthy mineral deposition. Only the basin at Green River city may safely be regarded as a self-contained electrochemical unit. In that compact area alone occur all requisite raw materials utilized in the manufacture of all commercial types of mineral fertilizers and many other chemical products.

Reservoir Base Map

Many exhibits of highly informative value appear in the previously cited Water Supply Paper of the USGS. An outstanding example is their map of the Flaming Gorge Reservoir site. That base map serves as the cardinal exhibit for this report. A full-scale photostatic copy of the map is inserted as the following page.

The USGS allowed only the regulation amount of marginal space for mapping the reservoir. No serious attempt should be made to superimpose all of the diverse geological phenomena that overlap one and another within the exceedingly small compass defined by the reservoir map. Nevertheless the borders were adequate to picture to scale the nearest approach of a fully self-sustaining electrochemical basin that


Complete Group
Transcontinental
Transportation Systems
U.P.R.R. - Lincoln Hwy.
United Air Lines
A.T.&T.Co.- W.U.Tel.Co.
EXTREME SOUTHWESTERN TERMINUS
LARGEST POTASH ROCK DEPOSITS IN U.S.A.
TWIN CITIES AIRPORT
ROCK SPRINGS
R.110W.
R.105
GAS MAINS TO LOCAL FIELDS
TO SALT LAKE CITY
HIGH-WATER LEVEL 6060
PORT OF GREEN RIVER
6055
6050
6035
KAPPES MINE
7½ MILES
6010
LOW-WATER LEVEL 6010
High-water contour
APPROXIMATE NAVIGATION TABLE
Reservoir Elevation Feet Above Sea Level | Location | Available Navigation
6060 - High Water Level | Green River City | 1 Mo.
6055 Level Reaches to | 1½ Mi. Below " | 3 "
6050 " " " | 3 " " " | 5 "
6035 Aver. Static Head | 5 " " " | 9 "
6010 Low Water Level | 9 " " " | 12 "
*Ice Locked During Some Winter Months.
ROCK SPRINGS COAL FIELDS
ENTIRE WYOMING AREA ON MAP
UNDER-LAIN WITH COAL BEDS
LARGEST PRODUCING DISTRICT
WEST OF MISSISSIPPI RIVER.
BAXTER BASIN GAS FIELDS
BIGGEST GAS RESERVOIRS
IN ROCKY MOUNTAIN STATES
GAS GATHERING LINES NET WORK TO LOCAL FIELDS
ROAD TO DAM
THROUGH NAVIGATION CHANNEL CONNECTING
Hydro Sites Chain With Coast-to-Coast Highways
Phosphate Deposits " Potash & Alumina Deposits
Basic Fluxes " Acid Fluxes, Soda & Gas
at Utah-Wyoming Saline Beds, Coal & Gas
State Line Fields in or near
GREEN RIVER, WYOMING
CLAY BASIN - NEW GAS FIELD
WYOMING
UTAH
FLAMING GORGE DAMSITE (41,000 H.P.)
RED CANYON DAMSITE - (57,900 H.P.)
SWALLOW CANYON DAMSITE (34,700 H.P.)
PARK CITY (LIMESTONE) FORMATION
PHOSPHATE BEARING
PHOSPHATE OUTCROP
DAM SITE (Proposed by Bureau of Reclamation, 1914)
POWER HOUSE
3 UPPER DAMSITES
Of Largest Interconnecting
HYDRO CHAIN IN THE ROCKIES
Extreme Southeastern Terminus of Biggest PHOSPHATE Deposits Known (36% World's Supply) Dam Site is Their Nearest Approach To National Markets.
(1) Sheep Ck Dam Site.
Back H2O 10 Mls
5 0 5 MILES
U.S.G.S. BASE MAP OF
FLAMING GORGE RESERVOIR SITE
ELECTROCHEMICAL BASIN
Data Superimposed
By C S Dietz
Cheyenne, Wyo. 7-30-38

is likely available in the U.S.A. or in any other major industrial nation of the world.

Not all basic supplies of the "Possessive" Green River community could be recorded on preceding sketch. The borders, however, were wide enough to show the characteristic types of resources that occupy superlative magnitudes on either the national or international picture. No attempt was made to show mineral deposits of ordinary size. For the location of several of them reference can be made to the larger scale map of Green River city, previously inserted.

The reservoir base map occupies almost 1/5 the area of an entire county in Wyoming. It also takes in a considerably smaller area in Utah.

The name of the Wyoming county is Sweetwater. It is not exactly a dormant area. It already heads the 23 counties of this state in taxable property. Its backlog of undeveloped wealth seems to be of ample dimension to lead the 3,070 counties of U.S.A. in valuation in the next century. Only a minor section of this promising area can be mapped out by the present investigation.

Major Resources Superimposed On Reservoir Map - Hydro Power

Primary prerequisite of a hydro basin worthy of the name is plenty of available hydro sites.

Room on the base reservoir map only allowed the locations of the upper trio of the Green River hydro-set. For locations of the complete quintette group of interconnected sites on the upper reaches of the scenic and precipitous Green it will be necessary to view the larger map next following.

There are no gaps in the preceding hydro chain. In their design for the local interconnected system, the USGS established dam heights that would back water to the units next above. Their philosophy probably contemplated completely regulated hydro development for the next 50 years to come. If an industrialist of the future finds power rates stiffening too rapidly, he could complete additional links of the local chain, as needed. The problem of unmarketable power surpluses should at no time be permitted to enter into a natural basin that can supply every essential to order.

Coal

It would be appropriate to place a carbon paper overlay on preceding base map. On Wyoming maps of the U. S. Bureau of Mines all of said area is underlain with high grade coal deposits. From the National view-point the Bureau's T. P.,#484, describes local deposits

as follows:-

> "The coal in the Green River region ranges from subbitumenous to high-rank bitumenous and probably exceeds in amount that in any other region of similar area in the country."

In other Federal publications local coal reserves are rated as high as one-half trillion tons.

For many years past the local region has lead the world in the art of mechanical mining. The district serves as a field laboratory to which major coal producing nations annually send representatives to study the latest technique in machine operation. The district is already 100% mechanized. Progress never stops at this point. The last word in modern mines will be the D. O. Clark, now under construction. Coal from this mine will be machine loaded and hauled directly on an endless belt system over a mile in length. Such big-scale automatic operations would provide a continuous fuel supply at lowest cost for firing conveniently located steam power plants.

In view of technological advancements of the local order described it is no longer possible to file an estimate on ultimate power production capacity of the so-called Green River hydro basin. Such an estimate would be entirely speculative.

In some of the older established hydro basins of the country power rates seem to be revised yearly, solely in the upward direction. The Green River type would automatically set an upper limit to such speculative procedures. In time hydro basins may be divided into 2 classes. The safe and superior basin will be a vast natural bin completely floored with coal and other fuel types.

No Transmission Lines

More than 90% of the local reservoir area will lie in Sweetwater County, Wyo. That county ranks first for tax payments in Wyoming. Most of these revenues are collected from coal mining and railway interests. Furthermore, more coal miners still reside in Sweetwater County than in the remainder of the State. In the past, hydro construction has seriously disturbed the welfare of all basic interests that have so far taken root in the locality, Obviously, no hydro plans of any sort should be projected for the community without allowing all

preceding organizations to have their day in Court. From such hearings neither members of Miner's Unions nor representatives of heavy tax-paying interests should be excluded.

A hydro project without any transmission lines leading therefrom would likely be the only kind that would receive local endorsement at this time. Such drastic stipulations would preclude average projects that have in the past flooded extended areas with surplus power capacity. Hardly one out of a thousand projects constructed by either public or private funds could meet exactions so severe. Yet all will agree that both construction and operating overhead would favor the project uncumbered by costly and decidedly wasteful transmission lines.

Take the city of Green River for instance. It possesses tremendous geographical advantages. In the Western Phosphate fields it stands 500 miles out in front of established competition for capturing national markets. Moreover, construction of the local reservoir would put rock in town for a few cents per ton. Such low cost transportation on basic ore supply is yet undreamed of at competitive points of equal civic importance within the entire Inter-Mountain phosphate province. Both of the preceding geographical positions may be dismissed at the outset. Just to reach the Port of Green River would require the construction of a transmission line 50 miles in length entirely along the shore line of the local impoundage pool. Ordinary arithmetic discloses the lower cost of operation at the power dam.

A Congressional Mandate requires a major New Deal agency to lower the cost of fertilizers to the agricultural industry. If such products are to be made at the ultimate rock-bottom cost it would be imperative to mine and reduce the rock supply at a single spot. The optimum point would necessarilly appear at the bus bar of a hydro project. Such locations can only be selected in completely self-sustaining hydro basins.

A phosphate plant for processing the rock at the Utah damsite would use coal mined in Sweetwater County. For quantity ratio see Cost Production Table sub-head to follow. Unfortunately, the new outlet would fall far short of the losses that local miners will suffer when the Seminoe Dam starts operations next summer. Half of its power output should have been conveyed to Green River for operating a phosphate plant

at that favorable site, but Part I of this investigation discovered that all of its firm capacity is already sold to municipalities situated within the marketing territories of the local coal mining district.

Only one kind of hydro project is of any good to the coal mining industry. The non-competitive project must sell its entire power output directly to the industrial market. In the past 15 or 20 years the municipal variety has succeeded in throwing thousands of coal miners out of employment. In the Green River dual coal and hydro basin hundreds of them could be rehired to mine phosphate and potash rocks. In areas much less advanced in engineering progress it seems that identical methods are utilized to mine both coal and phosphate rock beds.

In the completely self-contained Green River basin, fertilizer chemicals represent only one variety of products that could be processed at lowest costs. In time far more valuable and powerful chemicals will be manufactured there at production costs elsewhere unattainable. For hydro development solely in the industrial field, the Green River area offers a far wider latitude than any competitive basin.

Natural Gas

Every one knows that electric power is the most highly perfected form of energy yet introduced to industry. Members of the Community Club are already aware of the fact that gas from their local fields possesses twice the thermal efficiency of the artificial variety. Its same ratal supremacy also applies to all other common fuels like coal, ordinary coke and so forth.

The day is coming when a hydro basin barren of an exhaustless gas supply will be viewed pretty much in the light of an anachronism. In the future, manufacturing sites will be at spots that offer both of these increasingly important components of modern industry. The ideal heat and power combination provides the groundwork for the manufacture of the widest variety of cheaper and better products. If gas could be piped to the Niagara basin at the rates now prevailing in Green River, the standard of living would soon advance perceptibly in this country.

Several references have already been made in regard to the local gas fields. Other notices must follow. See preceding reservoir

map for locations of 3 fields compacted within the local hydro basin.

Oil

Liquid fuels must also be available at low cost for a hydro basin that would pretend to be complete in all particulars.

No oil fields appear on the preceding base map of the power reservoir, itself. Biggest and oldest field of the county for which Green River is the seat of government is the Lost Soldier field. It is plotted on the map next ensuing. Oil from this local field now goes to the new city of Parco for refining. The travel has been in the wrong direction for Parco lies 126 miles east of Green River.

Petroleum Coke

The only refinery product that space will permit mention in this preliminary outline is petroleum coke. This material also finds increasing application at major hydro points. Electrodes are made out of it. At Wilson Dam electrode consumption takes out no less than 7.7 cents from the TVA phosphate dollar. A local source of supply of this costly material should prove advantageous to towns that apply for locations of electrochemical enterprises from time to time in competition to Green River.

Cost of common coke represents 3.7 cents of the finished product dollar at Wilson Dam. Unfortunately, the prolifically rich Green River valley is devoid of coking coals. To make coke out of local fuels, Pike recommends a 40% admixture of Sunnyside, Utah, coals.

Strangely enough no experimentation has yet been conducted on the use of petroleum coke for local phosphate rock smelting. Lesser volumes of the Wyoming ash-free coke would be required for high temperature operations. Its B.T.U. rating is around 16,500 against the theoretical value of 14,175 for Tiffany diamonds of the first water. Use of the oil fuel in connection with the double-power natural gas of the locality would demand many precautions. The domestic markets for petroleum coke never did reach sizable magnitudes. In Wyoming its first application generally succeeded in melting the customer's cook-stove. For local smelting practice it would be well to adopt some measure of adulteration beforehand.

Phosphate and Potash Ore Supplies

The largest supply of potash rock in the U.S.A. approaches

within 9 miles of the northern end of the plotted reservoir site. At the southern tip the pool intercepts, at water's edge, the largest phosphate deposits known to the world. Incidentally, the latter point also represents the closest approach of the vast Inter-Mountain fields to the markets of the nation.

Total volume of these exhaustless rock supplies must be recorded in billions of tons. Few areas as variegated and compact as the mapped reservoir site are invaded by economic potentials of preceding magnitudes. From the local make-up chemical fertilizers of higher powered grades than now on the market must be processed in due course. Such products should be manufactured at costs beyond the pale of competition insofar as the Rocky Mountain phosphate province as a whole is concerned. Practical procedures for processing these huge rock supplies must be pointed out in subsequent chapters.

Acid and Basic Flux Deposits

The smelting of preceding rock varieties will require the use of both types of fluxing materials. On page 40, the operations of largest silica gravel works in the West were outlined. On completion, huge limestone deposits will also be flooded or bordered by the waters of the reservoir. These limestone ledges are, however, situated at the other extremity of the natural assemblage pool.

Prior investigators of industrial potentials in the vicinity of Green River never were able to locate limestone deposits closer than 119 miles to the city. Their transportation would have involved costly truck and railway haulages. Only by the construction of the local hydro dam will it be possible to haul requisite limestone fluxing material to the Port of Green River at a cost of a few cents per ton.

TVA Cost Production Table

Frequent references have already been made to the cost analysis sheet that H. A. Curtis and associates published in the December, 1936, issue of "Chem & Met" on the operating costs of the phosphate division of the TVA. The sheet is slightly out of date for the latest high-power products of the TVA. A copy, however, follows as a matter of record:

Table VII - Summary of Production Costs for Concentrated Superphosphate

Item	Annual Cost	Cost per Ton Available P_2O_5	Per Cent Total
Lump rock or sinter - - -	$550,966	$14.00	27.5
Phosphate dust - - - - - -	193,518	4.92	9.7
Silica pebble - - - - - -	29,792	0.76	1.5
Coke - - - - - - - - - - -	74,806	1.90	3.7
Coal - - - - - - - - - - -	1,915	0.05	0.1
Power - - - - - - - - - -	415,724	10.56	20.8
Electrodes - - - - - - - -	154,522	3.92	7.7
Water - - - - - - - - - -	15,614	0.39	0.8
Maintenance materials - -	70,264	1.79	3.5
Labor(all) - - - - - - - -	247,980.	6.30	12.4
Medical - - - - - - - - -	4,960	0.13	0.2
Storeroom - - - - - - - -	6,246	0.16	0.3
Depreciation - - - - - - -	181,682	4.62	9.1
Taxes - - - - - - - - - -	45,546	1.15	2.3
Insurance - - - - - - - -	4,960	0.13	0.2
Miscellaneous - - - - - -	3,904	0.10	0.2
Total - - - - - - - -	$2,002,399	$50.88	100.0
Credit for ferrophosphorus		2.97	
Net Cost - - - - - - -		$47.91	

By this time a local source of supply for each one of the various types of raw materials listed in the above table has been recorded.

To visualize the immediate sites of each one of these exhaustless deposits with one sweep of the unaided eye, it would be necessary to make an ascent of Tower Rock. A view of this prominent municipal configuration is provided by the 3rd photo appearing on page 38.

For surveyed locations of all listed ingredients, aside from coke, see preceding map of the local hydro reservoir site.

For location of a source for petroleum coke see the position occupied by the Lost Soldier Oil Field in the local county on the map next to follow.

For the operation of the electric furnaces at Wilson Dam, Alabama, it seems that TVA relies on various localities in central and western Tennessee for its phosphate rock supply. Other listed raw materials may come from elsewhere.

The TVA operates under a previously cited Mandate of Congress - - -"to improve, increase and cheapen the production of fertilizer and fertilizer ingredients." Only phosphates can be made at the TVA site. The Green River reservoir area doubles the latitude of the Tennessee-Alabama region for the manufacture of improved fertilizer products. For the processing of both phosphatic and potassic types at the cheapest

cost all raw materials should originate at a single hydro site, or say at the most, within the confines of a single county in Wyoming.

For reasons stated the membership of the Green River Community Club would welcome a broader interpretation of the basic Congressional Mandate now of record in the phosphate field.

A Venetian Highway

A glance at the preceding reservoir map suffices to disclose that all 5 forms of modernized transportation selected Green River City to route thru their original traffic from Coast to Coast.

To some minds such superb facilities are beyond improvement. As a matter of fact Green River is one of those towns that has travel accommodations only in an easterly-westerly direction.

To raise local standards of transport a full 100% provision must be made for an observable highway along a northern and southern route. Construction of the local power reservoir would provide the City of Green River with a Venetian Highway over which tremendous volumes of local raw materials could be barged at profoundly lower rates than those offered by transportation systems so far developed within that community.

Room was made for the insertion of a navigational table on the reservoir map. An inspection discloses that the City can be reached from any point on the 60-mile long pool during one month of the year at least. Five miles below the city the level of the reservoir will be sufficient to provide free navigation during the greater portion of the year. Only by the construction of the local waterway would it be possible to assemble all ingredients of the furnace charges at a minor fraction of the transportational costs prevailing at any other competitive point that may be named.

Several years ago the U. S. Dept. of Agriculture determined the "technical feasibility" of smelting local potash and western phosphate rock. In their T. B., #543, published a year ago, the following conclusion appeared:

> "The purpose of this investigation, as stated elsewhere, was not a study of costs but of smelting principles."

The Department used a small blast furnace erected near Wash-

ington, D. C. for their research work. Aside from potash rock, all raw materials seem to have originated from non-Wyoming deposits. From such widely separated spots it was hardly practical to file a cost analysis sheet.

During January, 1938, Robert D. Pike, chemical engineer, Piedmont, Calif., completed a report entitled, "Preliminary Estimates for the Production of Potassium Metaphosphate at Green River, Wyo." His report, yet unpublished, contains a map recording the locations and distances of all raw materials to be used in the manufacture of the proposed products. As his map shortens the distances of other investigators considerably, a copy of it follows:

The area occupied by the prior map of the reservoir site is outlined to scale on the Pike map. Note that a single postage stamp, airmail design, suffices to cover the reservoir site in which are far more severely compacted all raw materials, aside from coke, previously tabulated for an electric-furnace charge. A coke supply at 1/3 the previously plotted distance is also superimposed on the Pike map. Apparently, nothing would metamorphose the industrialization factor at Green River so profoundly as the construction of the fully self-sustaining Flaming Gorge hydro project.

Considering the reservoir simply in the light of a single assemblage pool unit, the following mileage figures are offered by way of contrast in respect to the plottings on both maps:

Raw Material	Distance From Green River Pike Map	Distance From Reservoir Pool - See Prior Reservoir Map
Phosphate Rock	157 Miles	0 Miles
Potash "	41 "	9 "
Coal	15 "	7½ "
Natural Gas Mains	1 "	0 "
Limestone Flux	119 "	0 "
Silica Flux		0 "
Soda Brine	0 "	0 "
	333 Miles	16½ Miles

A saving of 95%, precisely, in transportational assemblage is indicated by preceding table. That reduction, by itself, seems to be of appreciable magnitude. Eventually a saving around 97½% may result. Ordinary phosphate and potash rocks, common fuels, fluxing materials and the like can be towed a lot cheaper aboard scows than in railway gondolas, highway trucks and by other costly forms of rolling

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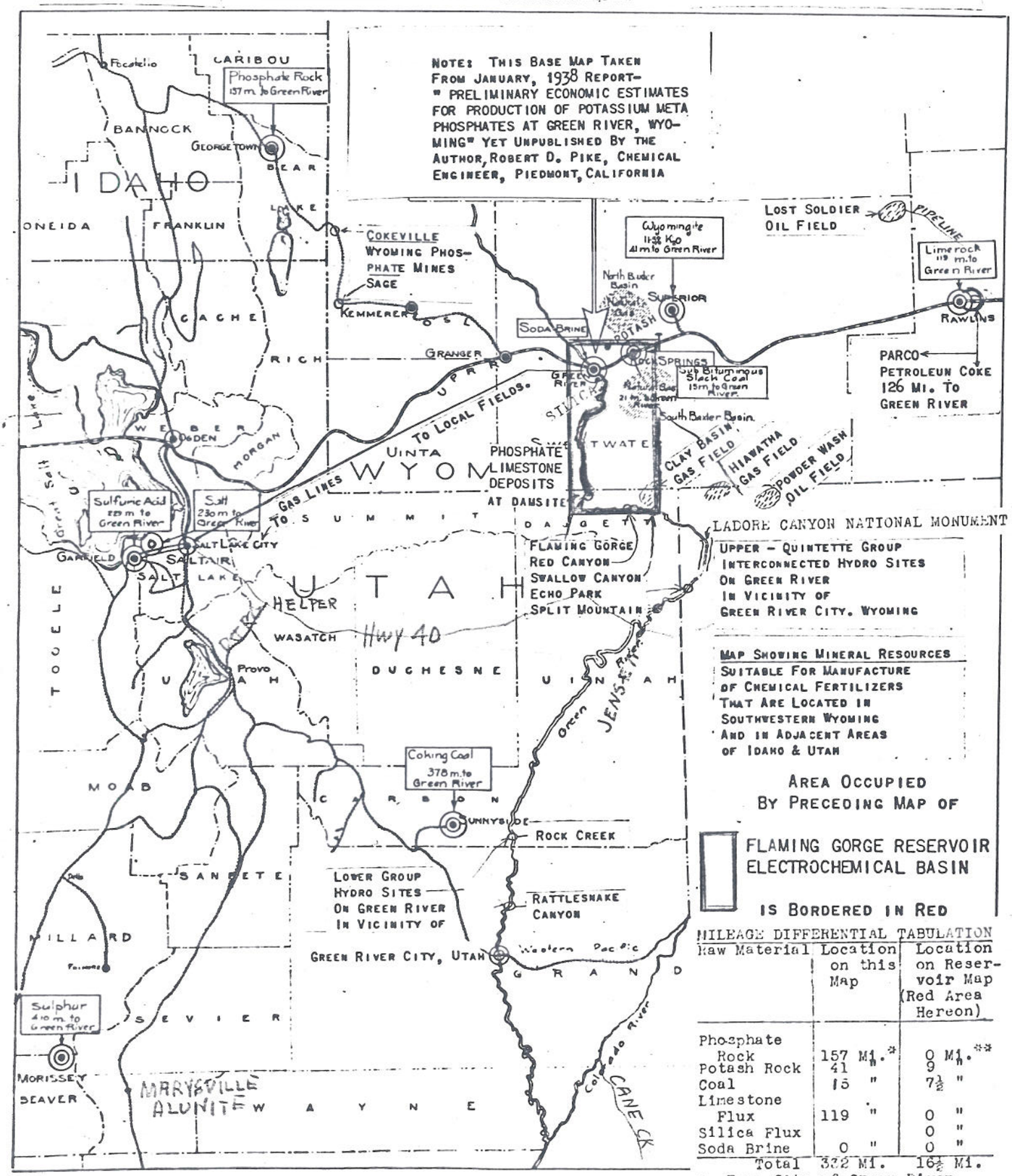
THE PROPOSED GREEN RIVER ENTERPRISE

APPROXIMATE SCALE
45 MILES = 1 INCH

SCALE
~~15 MILES = 1 INCH~~

PIKE AND WEST
CONSULTING CHEMICAL ENGINEERS
4068 HOLDEN ST. EMERYVILLE, CALIF.

ADDITIONAL DATA SHOWN IN TYPE
SUPERIMPOSED BY C. S. DIETZ



UPPER - QUINTETTE GROUP
INTERCONNECTED HYDRO SITES
ON GREEN RIVER
IN VICINITY OF
GREEN RIVER CITY, WYOMING

MAP SHOWING MINERAL RESOURCES
SUITABLE FOR MANUFACTURE
OF CHEMICAL FERTILIZERS
THAT ARE LOCATED IN
SOUTHWESTERN WYOMING
AND IN ADJACENT AREAS
OF IDAHO & UTAH

AREA OCCUPIED
BY PRECEDING MAP OF

FLAMING GORGE RESERVOIR
ELECTROCHEMICAL BASIN

IS BORDERED IN RED

MILEAGE DIFFERENTIAL TABULATION

Raw Material	Location on this Map	Location on Reservoir Map (Red Area Hereon)
Phosphate Rock	157 Mi.*	0 Mi.**
Potash Rock	41 "	9 "
Coal	15 "	7½ "
Limestone Flux	119 "	0 "
Silica Flux		0 "
Soda Brine	0 "	0 "
Total	332 Mi.	16½ Mi.

* From City of Green River.
** From Reservoir Pool.

equipment. Successful manufacture of chemical fertilizers in the wild and remote localities of the Rocky Mountain West is still regarded as an economic impossibility by several of the larger metropolitan journals. The necessity of seeking spots where all base materials could be assembled at a cost of a few cents per ton has been repeatedly stressed hereinbefore.

The distances plotted on the Pike map are not subject to criticism. His figures are based exclusively on available transportation services. On a tonnage basis 99%, plus, of the travel at Green River is still of an east and west direction. Apparently, a far more complete and variegated display of mineral resources is encountered by a trip to the southward. To encourage industrial development in the community, ways and means should be devised for low cost transportation on a volume basis in a natural direction. In the future more attention should be paid to the factor of geography.

Valuations

To provide Green River and mineralized territory contiguous thereto with a modernized source of industrial power, the dam at Flaming Gorge will be worth every dollar of its previously estimated cost of $12,000,000.

Among the civic betterments that will ensue from foregoing construction would be a permanent deep-water navigational channel, 60 miles in length. Availability of new type of transportation would permit the spot manufacture of phosphates and even more powerful fertilizers at low-cost levels, hitherto unachievable. As a vehicle - - -"to improve, increase and cheapen the production of fertilizers and fertilizer ingredients" - - the valuation of the latter supplementary navigational unit, alone, may be conservatively set down at $24,000,000.

The latter appraisal is filed solely for the benefit of the National agricultural industry at large.

Irrigation Vs. Hydro Development

At this time plans are being formulated for the irrigation of vast acreages of land situated in the Green River basin. The proposed schemes would divert 585,975 acre feet of water from the unused

flow of the river. No detailed examination of these embryonic proposals seemed to be justified for this investigation. A casual inspection indicated a long range, highly futuristic, if not, entirely visionary program of development.

The present writer made inspections of the several irrigation projects completed within the upper Green River drainage basin up to 10 years ago. Many of the major systems were complete financial failures. Some were built on bottomless gravel bars thru which irrigation waters flowed like in a sieve. Others were located in regions in which climatological maps show frosts occurring in every month of the year. Reclamation of seemingly benumbed soils of foregoing sorts is yet an extremely speculative procedure.

In due course the plans now under way will be reviewed by the U. S. Reclamation Service. Thus far the Service has completed 2 types of engineering structures within the Wyoming sphere. Acreages lying under irrigation projects completed 30 years ago yet remain unsold. Power outputs of hydro works have been complete sell-outs a year in advance of project operation. Sad to relate, some irrigation land sales consumated as long as 10 years ago yet remain unpaid. One type of customers have demanded extensions, reductions, and even omissions on overdue installments thruout prolonged periods of depression. No such system of financial complexities has yet been evolved by the customers of the power plants. Such sales are generally made to major utility corporations. They are executed on a cash payment basis.

Most irrigation propagandists are first and foremost state-right enthusiasts. The hydro project herein recommended for construction would be built beyond the boundary line of Wyoming. Hydro development does not consume or destroy latent water resources in any sense of the word. This report has suggested that water resources still remaining unexploited on the mighty Green be reused 6 additional times for hydro development in 2 lower down states.

In a frequently quoted reference volume published 10 years ago, a power propagandist stated:

> "the value of the products dependent upon Niagara power is reckoned in billions of dollars annually"

For 25 years or more phosphate rock has been hauled from

Tennessee to the Niagara Gorge for processing. At Flaming Gorge it would be cheaper to transport such lowly material from mine to furnace hopper by chain or belt conveyors. Regardless of the differentials between the cited haulage systems, the citizenry at Niagara still relentlessly battle every attempt to divert local water supply at any point thruout the tributary Great Lakes region. No one has yet pronounced the Niagara district a completely self-sustaining electrochemical basin. There the immediate mineral wealth seems to be limited to sand and limestone deposits. In billion-ton units one small reservoir pond on the Wyoming-Utah stateline would either overlay or else lay in juxtaposition to a wider diversity of mineral wealth than yet measured for the entire drainage basin in which the vast expanse of the Great Lakes occupies a central position.

The present National Administration seems to be preeminently dam-minded. For 25 years or more an organized band of irrigationists vainly sought the construction of a high-priced irrigation system in Wyoming. In a booklet published 5 years ago it was predicted that the revenue value of said system would be limited exclusively to its power producing potential. Three months after the publication date, the long standing irrigation proposals received Executive approval in an abridged form chiefly in the light of a power unit. Next year the new hydro works will be completed. Its power capacity is already sold.

At this belated day it would seem clear to all that one small hydro works would do the most good towards stimulating broad-scale industrial development in an outstanding, prolifically rich mineral depository. It would certainly return investment costs at a far earlier date than, say, big-sounding irrigation proposals calling for an ultimate expenditure of $50,000,000 or more during the next half century to come.

civilization must by a steady [illegible] park system.

National Recreational Area

Hydro construction at Flaming Gorge will appreciably amplify the channel of the Green in the lower section of the city, particularly during those intervals in which the power plant would operate at the maximum static head. Over-expanded irrigation inspiration would convert same sections of the river course into a baked, bone-dry channel during the latter months of the summer period. In time, the tax-payers of Green

River may be called upon for a decision on the type of marine scenery locally preferred.

The construction of the power dam would emplace the City of Green River on a permanently created lake of an area only exceeded by the Yellowstone in this state. It would be wrong to confuse the new lake with the huge mud ponds that are drained dry each year by the irrigation industry in this state. Minimum depth of the proposed pool would be 170 feet at the damsite. In such waters fish would thrive without annual danger of wholesale extermination.

Such construction would spectacularly transform the hitherto, generally arid, Green River community into a far famed recreational region. The beautiful lake would provide a marvelous anchorage for yachts, speed-boats and lesser forms of trim and neat racing craft. Unfortunately, many power reservoirs were or are now being constructed in regions far away from the beaten paths. At Green River the magnificent expanse of water would be daily visualized by thousands of auto, train, bus and plane passengers. Hundreds of the more vigorous visitors would doubtlessly tarry a day or two just to indulge in favorite aquatic pastimes that would range all the way from aquaplaning to yachting.

All will agree that the date is becoming propitious for the incidental establishment of one of these latest style National Recreational Areas directly across the Main Street of America. Between actual despoilation and visible enhancement of potential scenic values, the Administration in power seems to hand down only one type of decision.

It would be hard to file a monetary value on the recreational region that may later be created in the fundamentally dynamic Green River area. From the city a really fast speedboat could reach the dam in 60 minutes. A passenger on such a craft should experience an unusually exciting thrill. A previously exhumed citation rightly or wrongly pictured the locality of the damsite as one of the wildest scenic regions yet remaining unexplored in the U.S.A. Along the central arterial highway system of the nation, such sudden changes in environment are not everywhere available.

Advertising accumulated to date has measurably expanded the value of the novel features abounding in the attractive Green River region. Contingent evaluation of foregoing publicity may be minimized at $120,000.

Ladore Canyon National Monument

A step forward has already been taken towards the development of local river scenery into a recreational region. On August 2, 1938, Ladore Canyon was set aside as a National Monument.

Construction of the hydro project at Flaming Gorge will spectacularly improve all attractions that occupy the lower down reaches of the scenic Green. The power project would provide a minimum flow of 3,000 second feet to cascade thru the cataractal canyon every day of the year. Unfortunately, extended irrigation development on the upper levels of the Green would exhaust fully 90% of the preceding torrential flow during such intervals that the canyon would receive its greatest throngs of visitors.

Ladore Canyon is one of the finest scenic attractions still remaining in the primeval state in Colorado. At some points the canyon is 2,000 feet deep and the walls are as perpendicular as if cut by a knife. Its scenic value would indeed be problematical if only a trickle of water is allowed to pass over its precipitous floor during the height of the dual irrigation and tourist season.

The Ladore Canyon lies less than 20 miles south of that point on the Wyoming boundary where Colorado and Utah corner. The project at Flaming Gorge must always be viewed as a tri-state development in every sense of the word. Its extremely low cost construction in this day of big-scale engineering achievement is bound to receive the approval of both Colorado and Utah regardless of whatever attitude the Sovereign State of Wyoming may assume beforehand. Such development would visibly increase the scenic and hydro potentials of all 3 states. Much more costly irrigation construction within the Wyoming sphere, exclusively, would be preceded by interminable wars of words for reasons far too obvious to require further comment herein.

Two towns in Wyoming will likely receive the most benefits from an intensified program of development at the newly created recreational area. The map next preceding indicates that Green River and Rock Springs are the only cities of importance within hailing distance of the Canyon Ladore. In time visitors by rail or plane will be forced to embark from those points in odder to reach the latest National Monu-

ment in an expeditious manner.

Wider travel facilities may be provided in the future. The site yet unspoiled in the Colorado Wilderness never will receive National acclaim until it can be more leisurely approached from the Port of Green River. Gondoliers cruising over the Venetian Highway previously notated would encounter varieties of scenic grandeur rarely visualized in this or any other country.

Today, the scenic attraction of National endorsement nearest Green River is the Canyon Ladore. Scenery may also be listed among the natural resources that would develop traffic over a roadway leading in the southern direction from Green River.

CHAPTER III

GEOLOGY AT THE DAMSITE

Foreword - USGS Bulletin - Henrys Fork Area - Map - Type Section at Damsite - Limestone Deposits - Analyses - Reserves - Appraisals

Foreword

Within next few years sizable hydro works will be completed by several agencies of the Federal Government in at least 10 of the Western states. None of these projects are located within the vast area herein known as the Inter-Mountain Phosphate Province. Nevertheless, no type of raw material has been more frequently recommended for reduction at these new and remote hydro dams than lowly phosphate rock, itself.

Apparently, the more costly hydro works are approaching completion in regions almost barren of noteworthy mineral deposition. Three years ago an Oregon professor published a ponderous discourse in a leading chemical journal on the mineral resources that lie tributary to the Bonneville dam. Therein, the phosphate deposits of Wyoming and adjoining states were designated as the local raw material most suitable for providing market outlets for Bonneville power.

A mountain of phosphate rock would possess an appreciable value if it was moved from this locality to the Bonneville damsite. An Arctic iceberg might also be salable if it was towed to that vicinity during some seasons of the year. Unfortunately, more than 900 miles separates the Bonneville dam from the phosphate deposits on the Green River. Along the latter hydro channel it may not be necessary to go more than 900 feet from the damsite to secure a rock supply adequate for the operation of a phosphate processing plant of latest design.

The projects most frequently proposed for reducing phosphate rocks from the Western fields are the giant dams at Fort Peck, Montana, and at Grand Coulee, Washington. By way of contrast, power outputs of foregoing dams are respectively recorded at 10 and 65 times the volume that will later be generated at the Flaming Gorge natural site. Both of those proportionately more costly projects are, however, located

considerably nearer to the phosphates than the dam selected by the far seeing professor in Oregon. Their distances to the nearest operating mines are in the neighborhood of only 500 miles. Editors of the leading newspapers and technical journals maintain that the preceding distance is still too long for the profitable operation of phosphate plants.

The more stubborn of Eastern editors remain irreversibly convinced that phosphate works will never operate in the Western fields without receiving huge subsidies from the Federal Government. They never fail to expose the great distances that separate known deposits from nearest reduction sites. Other factors frequently objected to are the unfavorable geography occupied by the Western deposits in respect to National markets as well as the comparatively high cost of overhead operation still prevailing in localities heretofore singled out for receiving their censurious missiles.

So far as known no one has yet proposed a phosphate project that would be completely immune from the type of criticism still raging within the editorial world. This investigation failed to locate any such site totally within the confines of Wyoming. The following remarks are descriptory of a damsite lying 2 or 3 miles beyond the boundary of Wyoming.

USGS Bulletin

A search of the exhaustive literature published by the U. S. Geological Survey revealed only one citation of an occurrence of phosphate rock directly adjoining a sizable hydro damsite, itself. The notation of the Survey follows:

> "On both sides of the Uinta Mountains there are numerous large water powers that can be utilized in the manufacture of nitrates from the atmosphere or in the manufacture of commercial fertilizer from phosphate rock, atmospheric nitrogen, and rock high in potassium, such as leucite rock of Sweetwater County, Wyo. In the processes now used for the fixation of atmospheric nitrogen cheap power and cheap supplies of lime and coke or of limestone are essential. All of these except coke are present at many places in the range, but probably no locality is as favorably situated as the one on Green River at Horseshoe Canyon, where the Reclamation Service has made preliminary surveys for the erection of a large dam. At this point a large and cheap power can be developed, large quantities of limestone are present, and the phosphate beds as well as the overlying and underlying limestones cross Green River a short distance above the proposed dam site. When the dam is completed the stored water will flood Green River back to the Union

Pacific Railroad at the town of Green River and furnish cheap water transportation from the dam to the railroad. There are probably only a few places where power can be obtained cheaply enough and in large enough quantities to warrant an undertaking of this kind."

Above extract is from USGS Bulletin No. 690-C that was published in 1918 under the titular complex "A Geologic Reconnaissance Of The Uinta Mountains, Northern Utah With Special Reference To Phosphate." Other publications of the Survey were subsequently printed on the locality, but only Alfred R. Schultz, the author of the cited bulletin and long recognized as the foremost authority on Green River geology in the employ of the USGS took note of the phosphate occurrence at the prospective damsite.

The Survey bulletin mapped all of the phosphate beds discovered by Schultz within an area of 7,000 square miles in northeastern Utah. Only one of these beds intersects a hydro site. It alone lies within the industrial area tributary to the City of Green River. Many other beds are noted in the bulletin. Most of them seem to be too narrow or else too low grade to warrant exploitation at this time. No notice can be taken of such inferior deposits. All seem to occupy rough mountain terrain in positions remote from either navigation or railway transportation facilities. Obviously, such deposits will never serve as ore supplies for reduction plants that may later locate at Green River City or at the damsite, itself.

The bed at the damsite is described under the Henrys Fork area. Henrys Fork flows easterly in Wyoming for nearly all of its length. The phosphate bed, however, parallels the stream in nearby positions on the Utah side of the state-line. It dips toward Wyoming, but across the boundary the deposits are too deep to mine. The geology of the local area is sub-headed in the bulletin, as follows:

"Henrys Fork Area

The eastern phosphate area on the north side of the Uinta Mountains lies along the north flank of the mountains from 6 to 8 miles south of Henrys Fork and more or less parallel to that stream. At its east end, near the mouth of Henrys Fork, the phosphate beds lies less than 2 miles south of the River, and within a short distance they are cut out entirely by the Uinta fault south of the Boars Tusk, a prominent topographic point in T. 2 N., R. 21 E., 3 miles east of Horseshoe Canyon of Green River. The Henrys Fork area extends from the Boars Tusk westward to the divide between Burnt Fork and the East

Fork of Beaver Creek, a distance of approximately 30 miles. The general strike of the beds is east, although, owing to the minor irregularities in the main Uinta fold, numerous deviations from this trend were observed along the outcrop. The strata at the east end are in places nearly vertical and near the fault are largely overturned. The dip is generally to the north and varies from point to point, being as low as 15° in some places and nearly vertical in others. Near the west end of the outcrop the beds usually dip 35°-60°N.

The first low range of hills along the base of the main ridge in this area is due in part to its capping by the more resistant limestone ledges of the Park City formation. The quartzite beds in the upper part of the Weber formation, immediately below the Park City, are comparatively soft and weather readily, causing a depression between the base of the Park City beds and the lower part of the Weber formation. The dip slopes of the low front ridge are composed almost everywhere of Park City beds, and, as a result of the erosion which has occurred, the phosphate bed winds up and down the slopes between the higher points of the hills and the lower depressions along the valleys that cut almost at right angles across the strike of the beds. The phosphate bed crops out through much of the area south of Sheep and Lodgepole creeks and in the western part cuts directly across Lodgepole and Birch creeks and Burnt Fork. The phosphate beds are not well exposed at the west end of the area, but farther east the entire series is well shown. On the northwest bank of Burnt Fork in sec. 36, T. 3 N., R. 16 E., a prospect tunnel has been cut in the upper part of the cherty phosphatic limestone, presumably for copper. Two thin beds of phosphatic material were encountered, but the main phosphatic bed and associated shales were not opened by the tunnel, and it is probable that the prospectors failed to recognize the phosphatic character of the material penetrated. No measurement of the main phosphate bed or the Park City formation could be made from any of the natural exposures. The approximate position of the phosphate bed, however, can be located from the position of the underlying and overlying rocks and from the abundance of float along the strike of the beds.

On the west side of Birch Creek in the SW¼ sec. 34, T. 3 N., R. 17 E., fragments of phosphate float were picked up for analysis. An attempt was made to get a large variety of fragments in order to represent the entire bed from which the material was derived. After being ground together, all the material gathered proved on analysis (No. 29, p. 92) to contain 44.76 per cent of tricalcium phosphate. On the west bank of Lodgepole Creek in the SW¼ sec. 3, T. 2 N., R. 18 E., where the irrigation ditch has exposed the phosphatic shale series, a sample was collected from a 4-foot bed near the base of the series. This sample on analysis (No. 30, p. 92) yielded 67.28 per cent of tricalcium phosphate, clearly indicating the presence of high-grade phosphate in this part of the range. Farther east Lodgepole Creek cuts through the overlying beds and exposes the phosphate bed in the stream in the northwest corner of T. 2 N., R. 19 E., south of Jessen Butte. On the west bank of Sheep Creek south of the mouth of Lodgepole Creek a sample of phosphate rock was collected from a 2-foot bed. This sample represents a peculiar phase of the phosphate series not generally present or at any rate not readily observed, as it was seen for the first time in the section on Lodgepole Creek, where the irrigation ditch exposed the beds. Here, as well as on Sheep Creek, the 2-foot bed lies about 10 feet above the bed sampled on Lodgepole Creek and is not as rich in phosphoric acid as the lower bed. The sample on Sheep Creek (No. 13, p. 92) contained 58.21 per cent of tricalcium

phosphate, as compared with 67.28 per cent from the lower bed on Lodgepole Creek. Two other samples were collected from the phosphate series on the east side of Green River at the upper end of Horseshoe Canyon, in the SW¼ sec. 31, T. 3 N., R. 21 E. The stratigraphic position of the phosphate beds sampled at this point is given in the section on page 53, and the analyses of the two samples (Nos. 32 and 33) are given in the table on page 92."

Map

Foregoing phosphate deposits appear on the bulletin map as a single bed extending from the locality of the damsite on Green River for a distance of 30 miles to the westward.

The first 15-mile sector of the bed is redrawn as a broken red line on the map insert that forms page 71 of this report. Its positions in the immediate vicinity of the damsite are also superimposed on the detail plans sheet that is page 60 of this report. The Schultz map does not show the dam and its scale is too fine for accurate transferals on the larger plat inserts previously designated.

Schultz showed the outcrop to cross the river at 3 points. The upper crossing appears about 200 yards above the proposed dam. Below the dam 2 crossings appear within a distance of 2 miles.

The recorded analysis of 59.92 per cent is for rock taken at the upper crossing. If that content is satisfactory, a rock supply at water's edge would be available for operating a reduction works in the City of Green River. No analyses are recorded for the lower-down crossings. Those points would likely furnish the cheapest ore supply for a plant directly adjoining the power house.

Type Section At Damsite

Only one geological section was recorded along the route of the 30-mile long phosphate bed. As it was taken at the critical damsite location, it is inserted below:

"Section of Park City formation along Green River above Horseshoe Canyon, in T. 3 N., R. 21 E. (unsurveyed) Salt Lake meridian, Utah.

	Ft.	in.
Limestone and shales of the upper part of the Park City formation; resemble the beds on Brush Creek, on the south side of the range. Thickness not measured.		
Massive ledge of limestone - - - - - - - - -	15	0
Concretionary ledge of limestone - - - - - -	1	8
Phosphatic shales with thin beds of phosphate and bands of chert - - - - - - - - - - - - -	1	8
Thin black paper-like shales - - - - - - - -	1	6

	Ft.	in.
Phosphatic material (sample No. 33, p.92); 24.88 per cent P_2O_5; 54.49 per cent $Ca_3(PO_4)_2$ -	3	0
Thin black paper-like shales - - - - - - - - - - -	1	10
Phosphatic material (sample No. 32, p. 92); 27.36 per cent P_2O_5; 59.92 per cent $Ca_3(PO_4)_2$ -	4	2
Group of limestone beds at base of phosphate beds -	400±	"

The 4 ft. 2 in. bed of 59.92% phosphatic material is of sufficient width for economical mining. The thinner seams of leaner material may be disregarded at this time.

Limestone Deposits

The recorded section indicates plenty of varieties of massive limestone ledges suitable for low cost quarrying at this favorable water's edge location. Such rock could be cheaply barged to Green River for volatilizing the potash rocks of that locality. Heretofore, no limerock could be had at a low price in that city.

Analyses

The Survey bulletin tabulated 37 analyses for the Utah phosphate deposits. Only 2 were recorded for the 30-mile long main bed cited in this report. Their listings follow:

Location	P_2O_5	$Ca_3(PO_4)_2$	Thickness
SW¼ Sec. 31, T.3 N., R.21 E.	27.36%	59.92%	4' - 2"
SW¼ Sec. 3, T.2 N., R.18 E.	30.72%	67.28%	4' - 0"

A few analyses appeared for float rock and the thinner and leaner auxiliary seams that parallel the main bed. It would be best to disregard such figures. Their appearance here would cause confusion.

The first sample was taken from same quarter section of land on which the Flaming Gorge dam is located in other publications of the USGS. The second was at a point 15 miles west of the dam. Its analysis, 67.28% lime phosphate, is tops for all samples of actual ledge rock recorded in the bulletin regardless of localities.

No analyses are of record for the remaining length of the 30-mile long bed. None are necessary for such rock occupies too remote locations for exploitation at this time.

The cited analyses are plotted on the maps of this report.

The 67.28% deposit would require a 12-mile haul over local roadways to reach the deep reservoir pool. The waters of the huge reservoir would actually submerge the lower levels of the 59.92% ledge during all periods of the year.

Reserves

On page 94 of his report Schultz says:

> "Every acre underlain by a horizontal bed of phosphate 4 feet thick would yield approximately 14,000 tons and where the phosphate bed is steeply tilted the amount beneath an acre is much greater."

Only one of Schultz's beds was selected for discussion in this report. Its thickness is slightly in excess of 4 feet. In a prior citation its dips were recorded as ---"being 15° in some places and nearly vertical in others."

Hereinbefore, only the first 15 miles of the 30-mile long bed was deemed of sufficient merit to plot on the map inserts. That sector alone is within seeing distance of the intersected damsite. For calculating National reserves the USGS uses a vertical depth of 4,000 feet. For the Wilderness region in which the cited bed occurs only the top 1,000 feet of varying slope depths appears worthy of calculations at this time. On that presumption 2,000 acres of inclined material along a 15-mile outcrop would be completely underlain by a phosphate bed varying from 4 feet to 4 feet, 2 inches in thickness. The Schultz factor would indicate a total reserve of 28,000,000 tons of phosphate rock in the bed.

The calculated tonnage appears to be of an economic magnitude. As a matter of fact it would supply enough rock to operate the processing plant for which designs are filed herein for the next 200 years to come. All of this rock still seems to be owned in fee simple either by the Federal Government or in lesser amounts by the State of Utah. At $1.00 per ton, the value would be sufficient to finance the construction of 2 dams the size of the Flaming Gorge, and in addition thereto, 2 phosphate plants of the capacity herein recommended for construction. The latter underwriting would permit a plant at each end of the 60-mile long navigational channel. One of these could be located in the City of Green River and the other at the intercepted damsite itself.

Appraisal Variabilities

A tremendously wide range of figures is already available for filing appraisals on sizable phosphate rock deposits.

In an editorial dated August 1, 1938, a metropolitan journal severely censured TVA for paying $680,000 for 550 acres of phosphate bearing lands. The tonnage of pay rock contained therein was not mentioned. Records of phosphate beds over 3 feet in width are seldom accredited to the state of Tennessee in Geological literature.

The bulletin, frequently quoted in present chapter, maps 7,000 square miles of phosphate bearing lands in Utah. Apparently, that tract is of considerable value. At the cited quotation only one Government now operating under the sun could display sufficient gold stocks on hand to buy it. Fortunately, such a transaction could be avoided, for said lands are already owned by the preceding Government, itself.

One of the major Federal agencies is mandated by Congress to cheapen the price of fertilizers. Basic equities of preceding magnitudes continuously expand in economic importance. In the end it may prove cheaper for the Federal Agency, aforesaid, to move it works, lock, stock and barrel to a natural site in the Wyoming locality; even if it would decide to distribute all of its manufacturing output free of cost to all customers.

On the other hand valuation of all the phosphate deposits in Utah is rated as low as $0.00 by some members of the Community Club. No exception will be filed against the appraisal that occupies the cellar position on the scale. In some latitudes the mineral ice represents a salable commodity. At this moment the ice fields of the Arctic and the rock fields of Utah belong in the same category. Both appear equally isolated from developed transportational facilities. Measuring tonnages and calculating valuations for either of the preceding types of deposits may still be regarded as equally harmless pastimes.

Hereinbefore, ways and means were pointed out thru which a rock seam in the Utah wilds could be bodily transported to a strategically located, marketing outlet point at a cost of only a few pennies per ton. The industrial development potential still unreleased in that single seam might exceed all of the profits that would be harvested by the conversion of the local river course into a big-scale irrigation channel.

CHAPTER IV

LATEST DESIGNS FOR PHOSPHATE PLANTS SUITABLE FOR GREEN RIVER SITES

Irrigation vs Industrial Data - Plant Designing Problems - Published Plans - Plant Capacity - Cost Comparatives - Rock Supply - Stronger Report - Cokeville Rock - Power Cost - Coke and Coal Costs - Federal Plant Operations - A Technological Triumph

The superb resources of fuels, chemicals, raw materials as well as the present and prospective transportation facilities of the hydroelectrical basin at Green River would seem to assure a rich industrial future for that unique area. As a matter of fact no thorogoing, comprehensive, individualized, engineered survey has yet been conducted in that locality for any specific industry whatsoever. The paucity of data that still exists on some types of local deposits is appalling. Shortages of basic information may best be brought out by filing a contrastive parallel.

Irrigation vs. Industrial Data

For 40 years or more state and Federal agencies have daily gaged the stream flow of the Green River and tributaries at a score or more points in Wyoming. To date the number of these measurements may amass to 100,000 on the public records.

For filing the following plant designs, 2 assays are actually of record on a geological formation previously estimated to contain $28,000,000 in the form of pay rock. Both analyses would likely suffer rejection by an examining engineer. Neither value may prove sufficiently high for latest methods of ore reduction.

In recent years all major irrigation projects in the West have been financed by the U. S. Reclamation Service, exclusively. More than 2 gage readings are generally required before their designing engineers start work at any particular site. Beforehand the staff might ask if the pair of measurements were taken during the high or low water stage of the prospective irrigation channel.

During the several years last past other concerns than the TVA completed phosphate reduction works in the U.S.A. Elsewhere, plant designs were preceded by costly prospecting operations in every instance.

The less said about the 2 previously cited assays, the better

it may be to all concerned. In regard to their authenticity, Schultz made the following statement, to-wit:

> "In fact the appearance of the phosphate rock can not be relied upon in selecting the richest material, as the color, texture, and general appearance ofthe rock are very deceptive and the leanest-appearing portion may on analysis be found to be surprisingly high in tricalcium phosphate."

To this day no one seems to know if the samples of the Federal geologist were "high or low" grade rock. The laws of probabilities would strongly indicate the occurrence of considerable tonnages of both poorer and richer rock within the 15-mile stretch that intervenes his two sample locations. Perhaps the presence of the huge ledge itself would yet remain unheralded if both God Almighty and a farmer-irrigationist had failed to cut water channels thru the formation at the auspicious extremities sampled.

A bulletin published 10 years ago rated the industrial possibilities of the Green River basin above all other localities in Wyoming. Its conclusions aroused but little local interest. In the meanwhile some tragical mislocations have transpired within the industrial field. Had that precursory material been followed up with technical accurate reports it is possible that the entire power output of the Flaming Gorge project would now be consumed within the City of Green River without visible objection by the local coal mining industry. Later, room may remain for pointing out the depressing fates of one or two types of industries that failed to move into the Green River locality in the first place.

In Wyoming, public bureaus conduct a 100 surveys and reports on irrigation subjects for each inquiry undertaken of an industrial site. This disparity is not to be belittled. No state has yet produced a greater array of irrigation celebrities than Wyoming. The preachments of its irrigation statesmen, jurisconsults, engineers and executives have long been woven into the basic fabric of the law of the land. As a consequence, irrigation expansion is generally insisted upon even to the exclusion of all other manner of development. Such sentimentalities seem to be preeminently safe in most quarters of the state. At only a few spots would the continued inviolation of long established traditions lead to irreparable damage at some near or distant

date in the future.

Similar forms of conduct were recently in effect over broad areas in the West. In some neighboring sister states the propaganda of the irrigationists is rapidly being supplanted by the even more glamorous outputs of publicly operated electrometallurgical laboratories, institutes of phosphate research and similarly sounding titular organizations. At such centers it is no longer considered good form for an expert thoroly schooled in one science alone to condemn at random other types of wealth creating potentials that may yet remain unexploited within his immediate environment.

Plant Designing Problems

The date is rather premature to submit designs for a plant to process the big, 2-Assay phosphate ledge that intersects the favorably located hydrosite on Green River. It would be well to postpone that task until at least 1,000 analyses of the formation are available for more meticulous consideration.

Prior chapters accounted for the presence of other phosphate deposits in Southwestern Wyoming. The first and oldest mines in the Western fields are located at Cokeville, Wyoming. In fact no district in the West has yet reported higher grades of phosphate rock than those so far encountered in the richer beds of the Cokeville area. From that vicinity known supplies of approved rock could be hauled by railroad to Green River for treatment. That more distant rock could be processed in that city at a figure near the average cost that would prevail for operations within the Inter-Mountain phosphate province as a whole. Green River must still be regarded as a possible site for a phosphate works of the latest design.

Engineering progress in the phosphate industry is far more colorful than in the field of reclamation. A reduction plant completed a year ago might no longer be deemed practical for operation at a highly specialized site, say like the one that exists in the City of Green River. The complete group of TVA technologists continually evolve newer and better methods for treatment of rock remotely located, not only, from major markets, but also, from basic reagents formerly utilized by the older processing systems. If substantial achievement had not been made in this direction, it is doubtful if the TVA could be

induced to invade the promising Inter-Mountain province at any cost.

Published Plans

Work in the difficult and treacherous field of phosphate plant designing must be entrusted to specialists who have developed backgrounds based on years of devotion to the solution of research and operation problems.

The journal that leads in the publication of up-to-date phosphate plant designs is Chemical and Metallurgical Engineering. Last year that publication awarded their annual prize for industrial advancement in the chemical engineering field to a firm that completed an unique electro-furnace for the production of phosphorus.

The issue of June, 1938, contains designs for a newer plant that seems to be made to order or set apart for present-day operations within the electrochemical basin at Green River. On few occasions do technical journals release details and cost data of comparable informative scope in regard to problems of plant design.

The editor of Chem. and Met. is S. D. Kirkpatrick. In an earlier passage Mr. Kirkpatrick was listed as the chief disseminator of polit; co-technological information against pending proposals for phosphate expansion in the Western fields. At this point it becomes necessary to resort to his columns for last word information on modern plant construction. For the present investigation Mr. Kirkpatrick kindly supplied several copies of the report recently published in his journal. Apparently, his editorial expressions on Western affairs still remain unchanged.

Plans for the new plant were published in the article entitled ---"Full-Scale Production of Metaphosphate Achieved at Wilson Dam." Copies thereof are attached as Exhibit-A to this report.

The authors of the printed report are H. A. Curtis and colleagues, the principal chemical engineers of the TVA project. Note that the cost analysis statements are not based on laboratory data; but on actual operation of a full-scale works unit over the requisite period of time. Figures of corresponding authority are yet unavailable for consultation on the rock analogues occurring in Wyoming localities.

Plant Capacity

Annual capacity of the proposed plant is recorded at 51,400 tons of metaphosphate. Its operation would increase national output tonnage approximately 5%. That additional volume should be easily absorbed as some optimists predict a 10-fold expansion in phosphate consumption in the U. S. A. at no unduly distant date in the future.

Operations of the plant are based on the consumption of 154,950 tons of varying grades of Tennessee rock. At different sites on Green River rock would be fed into an identical plant carrying from 5 to 50% more phosphorus than the grades calculated for Tennessee. Expenses of operation in Wyoming should be no higher than in Tennessee. Yet, in one year's time the operator in Wyoming would produce from 5 to 50% more finished goods to sell than his competitor in Tennessee. Directly at the bus bar on Green River, phosphate rock could be mined at half the cost figured for the Tennessee plant. Such material savings are of appreciable magnitude.

In recent years several new phosphate plants have been completed in Tennessee. Why design additional plants for that increasingly popular locality? Pretty soon only editors of Eastern journals will be left to recommend Tennessee as the exclusive spot for safe investment in the phosphate field. More than geographical criticism may soon be required to protect that strongly entrenched region from an invasion of finished phosphates processed within the lower cost localities of Wyoming.

Power Consumption

The proposed complete multi-unit plant of the TVA's principal chemical engineers is based on the operation of 4 electro-furnaces. Drawing power of each furnace is recorded at 5,500kw. The four together would consume 29,300 of the 41,000 horsepower minimum that would be generated at the Flaming Gorge hydrosite. To consume nearly all of the power output it would be necessary to make room for another unit in the electric furnace building (See Fig. 6 for grounds plans of complete plant.) Such a supplementary unit would slightly reduce expenses in overhead operation.

Apparently, the selected plans could well be used for building a processing plant in Green River City. No major improvisations

would seem to be suggestible at this time. In formulating their ideas, the designing engineers of the TVA stayed well within the limits of power output capacity at the Flaming Gorge site. All must admit that the recently published plans of the TVA Technological staff were more closely tailored to fit the picture at Green River than any other hydro site in the Rocky Mountain West.

In the opinion of this writer an initial 4-furnace plant would meet all requirements at the Green River site. The latent power resources of that locality are of a too priceless value to exhaust on nothing more important than the production of metaphosphates. Nevertheless, construction of such a plant would cause an invasion of numerous chemical engineers into that long dormant locality. While ambling over the local perspective, some scenes quite suggestive of a well-stocked laboratory bench would doubtlessly be brought back to mind. Until the many unusual minerals and powerful reagents abounding in that locality are duly weighed for spot conversion into finished products, the true intrinsic value of the countryside will likely never see the real light of day.

More than one motive is behind the present investigation. Metaphosphates are only a minor item that could be produced at a lower cost in Green River than at competitive points within the U.S.A. In several localities thruout the world the fertilizer industry is closely tied to more important fields of chemical endeavor. In this report plant construction costs are merely regarded as the initial spark required for setting off a survey of sufficiently exhaustive dimension to set out the real potential wealth still reposing undisturbed in the Green River basin.

Cost Comparatives

It is a good thing that the TVA engineers designed their plant for a site other than Green River. Their discussion discloses authoritative operating costs in Tennessee as of June 1, 1938. Their analytical charts provide room for local study quite beyond the capabilities of the present investigation. At last engineers of the Green River community can make their own comparisons between local and Tennessee figures on a variety of raw materials costs.

Rock Supply

The chief expense of plant operation in Tennessee is ore supply. That item is listed at 29.41% of the total cost. In Wyoming that figure should be cut in two at the outset.

The ore supply situation seems to be more complex than what would exist in Wyoming. In the southern locality 2 different types of rock are smelted. Before a comparable can be filed with the one type available in Wyoming, considerable matter must be retabulated, to-wit:

Phosphate Type	Annual Tons	Analysis P_2O_5	Ton Cost	Annual Cost	Total% Cost
Nodules	126,350	24.5%	$3.50	$442,225	22.50
Lump Rock	28,600	33.0	4.75	135,850	6.91
Totals	154,950	*26.0%	*$3.74	$578,075	29.41%

* Average for Annual Tonnage

To operate the designed plant would annually require 154,950 tons of Tennessee rock carrying 26% P_2O_5 at an average purchasing cost of $3.74 per ton.

No phosphate rock has been produced in Wyoming in the last 6 years or more. It is cheaper to run a phosphate mine in Wyoming. The workable beds are from 33 to 100% wider than those in Tennessee. Latest available costs in Western fields is recorded on page 29. In 1936 a Montana mine is accredited with the production of 40,345 tons of rock at the mine valuation of $1.80 per ton of 2,000 pounds. In Wyoming surely 4 times that annual volume could be mined at $1.87 per ton which is just half the cost calculated for the proposed operation in Tennessee.

In the incomparable completely self-sustaining electrochemical basin of the Green River, $1.87 means rock FOB at the bus bar. To reach that absolute rock-bottom figure it was hitherto essential to seek out a hydrosite that directly intercepted a sizable bed of phosphate rock. On page 93 rock from such a site is tabulated. The first line listing discloses a 4 ft.-2 in. seam at that point containing 27.36% P_2O_5 (phosphorus pentoxide) the vital factor consumed by plant life. Note that the recorded content exceeds the drastic stipulations of the TVA engineers by 1.36%. That safety margin would yield the producer at FlamingGorge an extra 5% profit.

Several years ago a distinguished editor warned the consuming public on the futility of expecting P_2O_5 production at $40 per ton within the near future. That day has not yet arrived. In the mean-

while the TVA seems to have approached the desideratum closer than any other concern that publishes facts and figures. See their $40.66 net cost recorded in the concluding summary on attached Exhibit-A.

It is not hard to make a $40-price calculation at Flaming Gorge by the help of the figures recently published in the cited summary. Merely cut the total mining cost percentage (29.41%) in two and by adding the 5% production increase at that point a credit of $9.19 results. The subtraction indicates P_2O_5 production at $37.47 per ton at the damsite on Green River.

Stronger Report

A recent letter directed a stronger phosphate report in favor of Green River. A project that would use lots of coal was also logically suggested.

It would be possible to barge the rock from the damsite to town for $2 per ton at least during one month of the local navigation season. No serious objection would be filed against that price differential by an agency expressly mandated to lower the cost of phosphatic products. Private concerns also would doubtlessly prefer a site on the Main Street of the Nation to a location previously cited as an "Unexplored Wilderness." Furthermore it might prove difficult to retain an operating force within those pathless solitudes for any undue duration. Obviously, the cheaper site for a plant would be at a point that already provides all of the civic betterments usually available in a modern and civilized municipality. A tailor, however, must cut his cloth to fit the pattern.

So far no desires have been openly expressed for a high tension line to come into Green River. The entrance of a navigation channel into town would likely be even more bitterly opposed by local irrigationists. Unfortunately, the flow of the river is no longer adequate for both phosphate and irrigation exploitation on a big-scale basis. Today, no representative of a Federal or private organization now manufacturing phosphates would approve the city as a plant site until the preceding engineering groundwork was nearing the completion stage. A year ago local requirements would have proven to be far less objectionable.

Coal fired phosphate plants are no longer built. All new plants are electrothermically operated. Some years back a fuel fired

furnace was built in Green River for volatilizing potash rock. The temperature of the green electric spark is still considerably hotter than that of the ordinary blast furnace.

The 2nd most costly item for operating new method plants is power supply. The local mines are equipped to deliver coal on any volume basis demanded. The main difficulty is that corporations no longer build steam power plants for the major industrial markets. Their charges range from 200 to 300% higher than the rates filed in the attached designs of the TVA engineers. The differential would soon bankrupt a processing concern relying on steam for its local source of power supply.

Phosphate smelting is an energy consuming process. The new method industry wants lots of power but it wants it as cheap as possible regardless of the medium from which it is generated.

Cokeville Rock

The most authoritative geological volume extant on Western phosphate deposits is USGS P.P. No. 152. It was published for Idaho deposits. Nevertheless, the richest deposit tabulated therein is situated across the line in Wyoming. It is the 6-foot bed of 84½% of $Ca_3(PO_4)_2$ accredited to the Cokeville district on page 288.

Original intent of this investigation was to ship foregoing rock into Green River for processing with a power supply from the Seminoe Dam. That energy is already sold. The selection of a substitute power site and the location of new sources of rock supply directly contiguous thereto has already caused a 200% expansion in the contract length of this report. All of these complications could have been avoided. As early as 5 years ago the importance of diverting an appreciable share of Seminoe Dam power into Green River was duly broadcasted. Many benefits would have followed such provision. Irrigationists would not likely object to the arrangement and many pages of discussion on an irrelevant subject could have been eliminated herefrom.

Rock from the original Cokeville bed could be delivered in Green River at $3.74 per ton. That is the price recorded in the new plant designs of the TVA engineers. Its reduction in Green River would attract far wider attention than the average operation in Tennessee. The Wyoming rock carries 50% more P_2O_5 than the figure published for the proposed plant in Tennessee. If power supply charges are also identical

in both states, the processor at the Green River site should soon discover certain underlying factors working in his favor. At nearly the same cost of annual operation, viz, $1,569,844, the Wyoming plant should turn out 50% more tonnage in finished goods than its competitor, situated within the increasingly popular Tennessee locality. That extra million in sales slips would more than pay all freight bills even if all of the plant output had to be marketed exclusively in those states that lie at the remotest possible distances from Wyoming.

In Tennessee, processing companies seem to be increasingly finical in selecting sites for new plants. The current practice calls for a location within a suitable rock producing district already hooked-up with a Federal powerline. Had such preliminary prerequisites been locally staged as late as a year ago, a processing company would already be building a plant at Green River or some like favored spot that seems to be few and far between within the boundaries of the Inter-Mountain phosphate province.

In the next 5 years a considerable surplus of cheap hydro power will likely flood the markets of nearly all Western states aside from Wyoming. Thus far power consuming industries seem to display an interest in only one type of towns of the New West. Some local residents can already point out certain communities within the great phosphate belt that are now clamoring for the rock bottom rates on a magnet possessing no more drawing power than New Deal Hydro Power.

Power Cost

The final summary in Exhibit A records an annual operating cost for the proposed plant in Tennessee at $1,569,844. One-third of that sum ($537,840) is allotted for power cost. Another third, previously recorded at $578,075, was allowed for rock purchases. The remaining third accounts for the local payroll, minor raw materials, and also, taxes, interest, insurance, maintenance, depreciation and other general administrative miscellanies. No discussion need be filed on the final third subdivision. The variations for the several listings would prove inconsequential regardless in which state of the Union the newly designed plant is first built.

Preceding picture strongly indicates that only 2 factors are basically essential for the location of a low-cost phosphate plant. It

appears that power supply now rates 50/50 with rock supply cost. Many towns inside the vast phosphate belt can supply adequate quantities of rock. Other towns many miles outside of the belt offer plenty of power at even lower costs than the rates recorded in the TVA estimate.

Is there any town inside the belt that can supply both rock and power at attractive costs that is really in the market for a processing plant? Obviously, such a town must first be disinterred before operating companies will display further interest in regard to the limitless commercial possibilities of the greatest phosphate fields yet unbared in the world. Many towns both inside and outside of the belt have offered sites for phosphate works. Plants could afford to operate at most all of those competitive points if first granted subsidies varying from $100,000 to $500,000 annually. Thus far the technical staff of the TVA has failed to disclose any undue interest in optimistical inclined localities able to provide but one of the 2 preliminary prerequisites that are so essential for a profitable adventure into the phosphate field of endeavor.

Total annual power consumption of the proposed plant is recorded at 191,200,000 kw-hr. The supply is about equally divided between firm and dump power. The rates descend from 4 to C.6 mills, and the annual bill is averaged at 2.81 mills per kw-hr. It is extremely doubtful if any tax-paying unit will ever sell either hydro or steam power within the Green River basin in competition to the preceding rate structure.

No underground mine will likely produce large volumes of coal at lower costs than the D. O. Clark, the most modern of all Western mines. The mining and electrical engineers of the local mining organization should examine the power rates recorded in the TVA estimates. If steam power could be sold at foregoing rates, more than one phosphate plant would soon be built in the Green River locality. The processing costs would be sufficiently low for the plant outputs to enter nation-wide markets.

Power could be developed at a lower cost on the fundamentally dynamic Green than on the Tennessee River. Civil engineers now practicing in Sweetwater County need only glance at the Profile Sheet filed

as page 64 of this report to revindicate that allegation. The gradient of the Green is far more precipitous than the Tennessee; and along the latter channel, no vertical chasms of apparent knife-blade thinness do appear. For high static head construction, one cubic yard of engineering material on the Green would reach as high as 4 or 5 yards on the wider and less torrential channel already harnessed in Tennessee.

In recent months much criticism has been heard about the "yardstick" used to measure power rates on the Tennessee River. Apparently, senatorial inquisitors have thus far failed to ascertain if that stick is 18-inches or 3-feet long. No short yardstick would have to be employed for establishing power rate structures at sites like the Brown's Park canyon superimposed on the preceding Profile Sheet. At such local supernatural sites hydro energy could be developed at the lowest possible cost in the entire Inter-Mountain phosphate province.

The room-high stacks of maps, gagings, hydrographs, reports and other factual statistics that irrigation engineers have thus far accumulated on the Green are of but little value for calculating actual power development costs along that channel. Guessing that the latter expenses would be no higher than those prevailing for the Tennessee River, the power rate structure recorded in Exhibit-A designs will be held to apply to both streams.

Citable precedents are still few and far between in these less popular fields of investigation. Instead of the last horsepower already being harnessed, the latest USGS publication mentions that only 1,850 horsepower of a 760,000 potential is so far developed on the river and its tributaries. Green River offers apparent advantages for the location of a phosphate reduction works. Aside from rock supply costs, it is still difficult to contrast local superiorities by the aid of the mathematical language.

Coke Costs

Coke bills are recorded at only 3.93% of annual cost of operation for the proposed plant. Coke costing only $1.62 per ton would be delivered at the Tennessee site for $3.38 per ton.

The Wyoming rock carries from 5 to 50% more P_2O_5 than its Tennessee analogues. To reduce the richer ore, corresponding increases of coke would be required. Furthermore, ordinary coke costs consider-

ably more in Wyoming. In his latest 1938 report Pike estimates the cost of coke at Green River at $8.34 per ton. His material would be mostly made from local coals.

If petroleum coke can be used in the process, its cost in Green River would be around $6.50 per ton. The thermal and reducing value of this ash-free material is nearly double that of ordinary cokes. Accordingly, less petroleum coke may be required at Green River than coke breeze in Tennessee. The bill for coke at the Wyoming site may range from 5 to 10% of the annual cost of operation.

In the electric furnace process coke only plays the role of a reducing agent. In the blast furnace method it must in addition thereto produce the temperatures requisite to smelt the rock. The latter process steps up coke consumption around 500%. In a report published in November, 1929, in Chem. & Met., Vice President Klugh of Federal Phosphorus Co. recorded the b.t.u consumptions per pound of P_2O_5 produced at 9,213 in an electro-furnace; and at 45,000 in a blast furnace. In other reports coke bills are recorded as high as 66% of the total cost for blast furnace operations. In the Green River district the percentage ratio would even mount higher. Only the new method processes of the TVA and its predecessors would appear to be practical at the local site.

The Federal company pioneered in electrothermal practice. Klugh further reported that fuel economy is attained by directly converting coal into electric energy rather than using far greater volumes for manufacturing the coke supply required to fire blast furnaces. His steam power electrothermal plant was located at Anniston, Ala. Incidentally, coke is available at that point at only a fraction of the rates yet procurable in Green River.

It is no longer necessary to resort to either the coke or acid methods to process phosphate rock at a low cost. Neither one of the preceding commodities yet abound in the Green River region. Today, only one problem confronts Green River. Underwrite a sizable power development program first of all. If the price is right it would prove immaterial if the preceding groundwork was financed by the New Deal or by the coal mining companies of the locality.

Coal Cost

Cost of coal is recorded at $3.25 a ton for the proposed

plant in Tennessee. The Pike estimate is $2.50 a ton, FOB Green River. This lower coal cost would not offset the higher bills for coke that would prevail in Wyoming localities.

No further raw materials bills are tabulated in the cost summary of the TVA engineers.

Federal Plant

Operating expenses of a Federal plant should be much lower in the Wyoming-Utah field than in the Alabama-Tennessee district. No rock would have to be purchased, for in the local field the Government already owns many millions of tons of that lowly commodity. The potential value of these tax and royalty free equities would doubtlessly exceed the cost of plant construction by fully 50 times. For operating Federal plants at the lowest cost, no sites anywhere in the country would surpass those previously described for the Green River localities.

It is time for the Federal ownership factor to be utilized for lowering the cost of phosphates to the farmers. In Wyoming the Government also owns all types of fuel deposits. Yet the frequently cited summary is of little value for arriving at the true cost of a Federal operation in Wyoming. That commercial table is loaded down with numerous intangibles of appreciable magnitudes. All of them would be subtracted for the benefit of the farmer by a Federal operation in this area.

Taxes and interest are more tangible factors that would also largely suffer elimination from a cost analysis sheet filed for a straight-through, From Raw-rock - To - Finished-product operation of the Federal Government. Farmers never will obtain cheaper phosphates until multifold forms of front-office, overhead operating non-essentials are pared clear down to the bone, preferably within a duly qualified valley in Wyoming.

A Technological Triumph

The proposed plant is designed to manufacture the latest product of the TVA, a high-power fertilizer containing an available P_2O_5 content of 65.4%. The new concentrate carries a 30% higher efficiency rating than the 50.5% P_2O_5s made by the TVA and competitive concerns up to a year ago.

Cost of manufacture of the newest product is several dollars

higher per ton than the phosphates formerly sold. Nevertheless, one of the tabulations in attached report discloses a minimum saving of $8.89 per ton for the new type of phosphates delivered on the farm. In the final analysis the farmer now receives the equivalency of 10 tons of phosphate at the cost he paid for 9 tons a year ago.

The latest triumph of the TVA technologists was widely heralded in the press despatches of last May. The announcement has already produced noticeable effects on the editorial page. Far less criticism has since been heard on the remoteness of the Western phosphate fields for possible commercial exploitation. Manifestly, the higher the degree of value concentrated into fertilizers, the farther such products will travel from their point of manufacture.

Geographically speaking the newly developed process of the TVA has bodily moved the City of Green River at least 10% closer to the major consuming centers of the Nation. That distance is appreciable. For invading National markets, a prior statement indicated that Green River already stands 532 miles out in front of competition thus far established in the Western field. Thanks to a distant industrial achievement, the phosphate expansion picture at Green River is considerably brighter today than say as late as one year ago.

From now on members of the Community Club can loftily ignore whatever editorial spinach big metropolitan journals may continue to cast in the direction of their [illegible] strategically situated locality. Apparently, a major advancement in science has measurably diluted the effects of detractory words recently hurled against the merits of the Western phosphate fields as a whole.

Sixty-five point four doubtlessly represents the ultimate maximum degree of efficiency that can be built into fertilizers processed in the Tennessee River valley. In the Green River valley 65.4 would be the starting point minimum for the higher powered manufactures significant of the community. For only in the one and complete electrochemical basin could the TVA or any other similarly inspired technological organization step up the efficiency ratings of processed fertilizers an additional 30% from raw materials occurring at a single spot.

CHAPTER V

POTASH ROCK DEPOSITS

Foreword - Geology - Mineralogy - Analyses - Recovery Investigations - Smelting Processes - Indicated Efficiency Rating Tabulation-"X" Method - Bureau of Chemistry Processes - Pike Process - Supplemental Process - Manufacturing Costs - Federal and State Investigations - Summary

Foreword

Few nations contain extensive deposits of potassium, phosphorus or nitrogen compounds. These elements form the grand triumvirate of mineral fertilizers consumed by plant life.

Up to the time of the Great War, the world had to rely on iron-clad monopolies for its supply of two of the preceding elements. Since that time a major scientific achievement has freed all major powers from the nitrogen monopoly long operated by the Chilean Government. More recently other factors have served to impair the control that the Imperial German Government once exercised over the potassium markets of the world.

A growing number of chemists no longer regard a direct application of nitrogen salts as essential for maintaining soil fertility. Soils containing adequate amounts of potash and phosphate now seem to be capable of manufacturing their own nitrogen requirements. Unfortunately, extensive deposits of the two mineral foods yet remaining indispensible, are usually separated by some thousands of miles. As a result, all nations continue to rely upon distant over-seas shipments for large supplies of one or both of the preceding minerals.

A unique situation seems to exist at Green River. An inspection of the map on page 71 strongly indicates that Green River is the one point in the world where huge deposits of both potash and phosphate rocks could be hauled to town for processing at a cost of a few cents per ton. Plenty of sites seem to be available in America as well as in the rest of the world for the manufacture of either potash or phosphorus compounds. Thus far only one point is known to possess all of the potentials required for the operation of a completely integrated fertilizer industry. That extraordinary focal point is Green River, Wyoming.

Geology

The map of the local electrochemical basin on page 71 shows that the largest potash rock deposits in the U.S.A. approach Green River within a distance of 9 miles. That nearest deposit is Pilot Butte, one of the 20 volcanic necks and knobs of rather bizarre appearance that spectacularly adorn the 350 square miles of highly individualistic desert scenery locally known as the Leucite Hills.

In 1912 the U.S.G.S. published Bulletin No. 512, entitled- "Potash-Bearing Rocks of the Leucite Hills, Sweetwater County, Wyoming." Its joint authors were Schultz and Cross. Therein, the weight of the available leucite rocks was totalled at 1,973,496,177 tons. Their potash and alumina contents were each recorded at 197,349,617 tons. Those combined weights were estimated at 20% of the total rock mass, itself. In point of volume, no domestic reserves of potash or alumina approach the tonnages yet unisolated in the molten lava extrusions that formed the Leucite Hills of Wyoming some 40 or more million years ago.

Rock primaries of such high potash content seldom appear in any portion of the Globe. Their geology has fascinated academicians for many years past. Conventional descriptions of these rocks may well be disregarded at this time. The composition of these lava flows are about as uniform as a batch of glass. Furthermore, no scientist has yet questioned the exhaustibility factor of these tremendous deposits. However, the transformation of these huge masses of unpayable rock into profitable ore does not belong to the province of geology.

Mineralogy

Mineralogical literature accummulated to date on the local potash rocks is of sizable dimension. Their external characteristics and microscopic features are best described in the cited USGS bulletin. Various authors use different names for these rocks. The dense, generally reddish rock consisting of leucite, diopside and mica is now called Wyomingite. The name is appropriate for no very similar rock is known from any other part of the world.

Analyses

About 20 partial and complete analyses were published on the

leucite rocks in the Federal bulletin. Those figures show the potash lavas to be far more uniform in composition than the phosphate rocks that also occur in the local region. The potash and alumina variations are all within 2% of the average contents previously recorded.

The silica in the lavas averages 53%. Deviations from the preceding mean are not over 3% in the analyses of record. One-third of the silica is in the free and uncombined form. Several processes have already been formulated for using this highly acidic rock as a flux to smelt the basic phosphate rocks of the locality. Obviously, their efficiency ratings are somewhat below the silica gravels now used at Wilson Dam. Several compensating values would however be yielded by the Wyomingite substitution.

The Orendite, No. 6 analysis appears slightly more attractive for local smelting practice than other material tabulated in the USGS bulletin. Some of its leading values follow:

Potash	11.91%
Phos. Oxide	1.59
Alumina	10.16
Iron Oxides	3.99
Titanic Acid	2.67
Silica	54.17
Lime	4.19
Magnesia	6.62
Na_2O, SO_3, FI,) H_2O, et al.)	4.91
Total	100.21%

The preceding potash content slightly exceeds the 11.31% recorded in USDA, TP, #543 for Wyoming rock smelted in Washington by the Bureau of Chemistry. Plenty of rock of foregoing grade remains in Wyoming for further smelting.

Note the appreciable phosphate content in the potash rock. The Wyoming phosphate rocks also contain minor amounts of potash. Slightly higher recoveries could be expected from such admixtures in the furnace. Ferric oxide is also present in the Wyoming phosphates.

Past investigators used 2 tons of potash to 1 ton of phosphate rock in their furnace charges. Such mixtures would yield higher ferrophosphorus values than now recovered in Tennessee. The latter by-product apparently finances 15% of the cost of operation at the TVA plant.

The presence of 2.67% titanium dioxide in the local potash

rocks is of some conjectural interest. That metal as well as minor amounts of vanadium and chromium are present in the phosphate rocks of Wyoming. At the temperature levels in which phosphate rocks are now smelted in the electric furnace, all of the preceding ferro-alloy values would likely be lost in the slag. Recently some progress has been made in extracting low vanadium contents from the slags of German steel works.

Recovery Investigations

Scholars of the past frequently sought to release the potash values contained in the highly refractory Wyomingite rocks. More than one doctorate degree has already been awarded for the solution of that problem on the laboratory bench.

Exploitation for the potash content of the local lava rock has also been the subject of many patents and processes of widely divergent character. Some of these schemes look good on paper. Their commercialization, however, has hardly passed the state of disorder and jumble that confronted the phosphate smelting industry, say, as late as 10 years ago.

Smelting Processes

A number of papers are already available on the smelting of wyomingite. In some investigations only the latter rock was placed in the blast furnace. In other instances it was combined with the phosphate rocks of the locality. Some of the processes consume tremendous volumes of raw materials. Such systems are only of scholastic interest. In the following tabulation the varying raw material requirements of 5 local blast furnace investigations are compared to the performance of the latest type of electric furnace used by the TVA for smelting phosphate rock, exclusively.

INDICATED EFFICIENCY RATINGS FOR SMELTING PROCESSES

	Minimum Raw Materials Requirements					
	Electro-Furnace	Blast Furnace Systems				
Method	TVA	X	U.S.Bureau of Chemistry & Soils			Pike
Ton of Product	P_2O_5 65.4%	KPO_3 83%	KPO_3 83%	K_2O 100%	P_2O_5 100%	KPO_3 92%
Material (Tons)						
Potash Rock		2.89	3.26	10.03		160
Phosphate Rock	*3.01	1.60	1.53		*3.68	201
Coke	.41		1.54	4.07	2.00	150
Coal		2.50				
Limestone		2.56	2.57	9.11		
Silica Gravel					0.99	
Calcium Chloride			0.43	1.29		
Total Tons	3.42	9.55	9.33	24.50	6.67	**7.56
***Indicated Efficiency Rating	100%	46%	47%	21%	78%	64%

*Tennesee rock used. Wyoming equivalencies available
**Includes Potash Rock used in Supplementary Process
***Based on 100% Plant food Content

Foregoing table discloses that 3.42 tons of raw material produces one ton of finished product in the electric furnace. In the blast furnace from 6.67 to 24.5 tons are required to make one ton of the higher grade fertilizers. As tabulated, the electric furnace seems to be from 30 to 500% more efficient than the blast furnace in regard to tonnages of raw material consumed.

Criticism may be filed against the method used to establish the efficiency ratings of the several furnace systems listed. In smelting economics input costs nearly approach output sales in factors of basic importance. For some listings the raw materials cost would exceed the value of the finished product. The preceding tabulation should automatically exclude such processes from further consideration.

"X" Method

Published reports are attached hereto for 4 of the listed blast furnace investigations. The remaining X method is described in a letter report that was addressed to a former Senator of Wyoming several years ago. As the latter communication covers basic principles with the fewest words and calling for the widest use of local raw materials, a copy thereof follows:

MR 38-4

"Dear Senator -----:

Pursuant to our brief conversation of Saturday, and in compliance with your request that I provide you with our estimates of what it would cost to produce potash from the mineral wyomingite, I submit the following representing a calculation based on our experimental results.

A fertilizer blast furnace is proposed located at Superior, Wyoming, and designed to smelt the locally available potash-bearing rock (wyomingite), using locally available soft coal. There would be required two additional raw materials to be brought in by rail, (1) phosphate rock from Georgetown Canyon, and (2) limestone from Rawlings. Both are delivered to the plant by short rail haul by the Union Pacific.Railroad. The cost per ton (2000 lbs.) of these four raw materials delivered at the furnace, including freight on phosphate rock and limestone are estimated to be

Wyomingite rock (12.76% potash)	$0.90
Soft coal (47.5% fixed carbon)	2.25
Phosphate rock (31.5% P_2O_5)	3.75
Limestone	2.75

The product shipped to the fertilizer market would be phosphate of potash (monopotassium phosphate) containing the following plant food values:

Available phosphate	50%
Available potash	33.2%
Total plant food	83.2%

A furnace to manufacture 200 tons per day of this phosphate of potash is estimated to cost $350,000 erected. The materials required per day would be

	Per day	Per year
Coal	500 tons	150,000 tons
Wyomingite	578	173,000
Limestone	514	154,000
Phosphate rock	320	96,000
		573,000 total annual tons

The cost per ton of potassium phosphate would be:

Per ton of product	
2.5 tons coal at $2.25	$5.63
2.89 tons wyomingite at $0.90	2.60
2.56 tons limestone at $2.75	7.04
1.6 tons phosphate rock at $3.75	6.00
Cost of raw material(f.o.b.furnace)	$21.27

The pay roll would run $500 per day. An annual capital charge of 21 per cent to cover taxes, interest, amortization, depreciation, and obsolescence, would amount to $245 per day. These charges per ton of product are therefore $2.50 for labor and $1.23 for capital.

The cost of the product at the furnace totals, per ton

Raw materials	$21.27
Labor	2.50
Capital	1.23
	$25.00

It is estimated that the freight from Wyoming to Atlanta, Georgia, will be $10.50 per ton in carload lots. The cost of product, f.o.b. Atlanta, is

$25.00	f.o.b. furnace
10.50	Freight
$35.50	per ton

The present wholesale price of the fertilizer materials, phosphate and potash, as quoted on favorable low-price contract to the manufacturers of mixed fertilizers for the lowest grade and cheapest materials is

Superphosphate (16% phosphate) at $7.90 per ton Atlanta
Muriate of potash(50% potash) at $35.00 " " "

Per ton of plant food, the price is

Phosphate, $7.90 divided by 0.16	$49.30
Potash $35.00 divided by 0.50	70.00

A ton of phosphate of potash is worth, therefore,

50% phosphate at $49.30	$24.65
33.2% potash at $70.00	23.20
Value of product in Atlanta	47.85
Cost of product in Atlanta	35.50
Profit per ton	12.35
Profit per day, 200 tons x $12.35	$2470
Profit per year(300 days operation)	740,000

Time required to pay for plant investment of $350,000 5 months, 20 days

Atlanta approximates the center of the present fertilizer industry. There the competing products are the cheapest and the freight from Wyoming the highest. The logical market for the Wyoming market is the great agricultural middlewest.

Wyoming has large deposits of phosphate rock. However, the nearest deposit of high-grade rock of which we have detailed information is at Georgetown Canyon, Idaho.

Figures such as these, I admit, do not find ready acceptance without an actual demonstration. We are now attempting a demonstration, not on any commercial scale, of course, but we hope on a scale large enough to warrant private capital in proceeding with its own demonstration, with a furnace intermediate between our own and the unit herein proposed.

If I can provide you with additional information, please command me.

Very sincerely yours,"

A copy of the foregoing report was received for an investment analysis. Several of its conclusions are of a far too optimistic vein to warrant an extended review.

The forecast that 83% potassium phosphate can be produced in Wyoming or elsewhere at $25.00 per ton seems premature to say the least. Note that no less than $21.37 of that sum was totalled for the cost of raw materials, alone. Only $2.50 was allowed for the payroll. To meet the going wage-scale, the latter figure would have to be multiplied by at least 5 times. The ridiculously low capital charge would suffer an expansion nearer 10 fold. In the forecast nothing at all was allowed for taxes, depreciation and other costly items of operation.

It would seem cheaper to manufacture fertilizer by the electric method listed in first column of the page 115 tabulation. By that process 3.42 tons of raw material yields one ton of finished product. The tabulated X method requires 3 times that volume. The labor and capital charges for the smaller plant have already been fully recorded. Obviously, the handling and overhead expenditures of the bulkier proposals would be proportionately higher.

Worst feature about the "X" scheme is the 4.16 tons of Idaho phosphate rock and Rawlins limestone that composes nearly 50%

of the furnace charge. At the hydrosite on Green River such rocks would serve for the foundation course of the furnace itself. Such a location would completely eliminate the raw material haul of 576 ton-miles required by the "X" proposals. That saving would suffice to haul the finished product a long ways into competitive marketing territory.

The necessity of locating a non-subsidized reduction works on a spot in the Inter-Mountain phosphate province that provides by itself 88% or more of all raw materials has been repeatedly stressed hereinbefore. To make a ton of finished product only 0.41 ton of coke now needs to be hauled from the outside to a logical hydrosite lot on the Green River. Obviously, that lighter haul more than decimates the 4.16 ton-load already totalled against the X scheme.

To reduce fuel bills Mr. X selected a coal mine for the site of his plant. The location is logical for proposals that require over 6 times the fuel consumption previously tabulated for the Green River type of plant. His figures disclose a coal cost of $5.62 for each ton of fertilizer produced at the mouth of mine. It would be cheaper to haul 0.41 ton of coke at a natural hydrosite on Green River.

Mr. X coolly calculated the "time required to pay for plant investment of $350,000" at exactly 5 months and 20 days. His project may never receive financial endorsement until his time-interval forecast is also multiplied 10 fold. His prophecies are strongly suggestive of the swivel chair calculations frequently performed by bureaucratic research workers. Today, the economic fallacies of pedants are no longer expected to survive the arithmetic of school boys.

Credit should be given to Mr. X for filing the first report on the manufacture of double compound fertilizers in the Green River area. His economics may be in error, but subsequent experimentation fully established the correctness of his furnace charge calculations. His original report clearly explains the principles of all smelting processes hereinafter cited. It therefore makes good introductory material for this report.

Bureau of Chemistry Processes

The tabulation on page 115 lists 3 blast furnace methods of

the Bureau of Chemistry. Complete descriptions of all of these processes appear in Technical Bulletin No. 543, that was published in April, 1937 by the U. S. Department of Agriculture under title of "Blast-Furnace Processes for the Production of Phosphatic and Potassic Fertilizer Materials." A copy of that out-of-print publication is attached to this report as Exhibit-B.

All processes of the Bureau follow the general principles quoted under the X sub-head immediately preceding. Their procedures are fully set forth in the attached exhibit. The indicated efficiency rating of each one of those processes for operations within the highly specialized field at Green River is recorded on the tabulation sheet frequently referred to herein. Those comparative ratals were prepared with the view of eliminating frequent reference to the more exhaustive descriptions appearing in the bulletin exhibit.

The No. 3 process of the Bureau tabulated on page 115 is for the production of P_2O_5, phosphorus pentoxide, exclusively. It is the regular blast-furnace process. Against the cheaper electric furnace, its efficiency rating is listed at 78%. The only difference between the two methods is the heating agent. Coke is used in the blast furnace, and in the electric furnace all of the heat is supplied by electrical energy.

Ordinarilly, both of those thermal agents are costly. In the Green River area, hydro energy would be produced at the lower cost.

The bulletin of the Bureau of Chemistry was published only a year ago. Already its blast furnace process appears to be out of date, even in regions of low-cost coke supply. The operations of a company that found it cheaper to transform coal into electrical energy for firing their phosphate furnace were previously cited on page 108.

No blast-furnace construction for smelting phosphates in the Green River locality is sanctioned by this investigation. At this time various pressure groups are working for the establishment of little TVA's at several points in the vast Inter-Mountain province. At such sites phosphates would be reduced with New Deal hydro-power at lower costs than possible to attain by blast-furnaces operating in Green River and elsewhere. No subsidized industry of any sort should be sought in regions that contain resources of the magnitude and

variety present in the Green River area.

The Bureau of Chemistry also evolved a process for smelting potash from the local wyomingite rock. On preceding tabulation, its efficiency rating is recorded at only 21%.

The reason for the low efficiency factor is that a furnace charge of no less than 24½ tons was used to produce one ton of potash. Such a process would require a whole freight train of rock and fuel to manufacture only a carload or two of salable product. The energy consumption in heating all of that prodigious volume of rock to extremely elevated temperatures would simply prove terrific. Obviously, no cheap method was sought by the Bureau research workers for the extraction of potash from the Wyoming rock.

Hereinbefore, the economic hazards of smelting rock by a process in which raw material assemblage constituted 85% of total cost of operation were briefly pointed out. No similar resume need be filed on the Bureau's potash investigation. Instead of only 9½ tons, their experimentation required no less than 24½ tons of even more expensive material for the furnace charge. The cost of that mountainous admixture of rock, flux and fuel would safely exceed actual market value of the recovery product sought by more than 185%. The economic objects of such forms of research endeavor are not everywhere understood. However, the serious-minded investigators filed the following conclusion in defense of their labors:

> "The conclusion is drawn from table 14 that commercial potash smelting appears feasible only when low-cost limestone and fuel are available. The information given in this bulletin in regard to the operating conditions involved in the blast-furnace process is, however, of fundamental importance because the existence of a technically feasible potash-furnace process should operate to set an upper limit to any future rise in the market price of potash."

Much of the original research work, aforedescribed, might have been avoided. Twenty years before an industrial concern amply established the technical feasibility of smelting local potash rock on a big-scale basis. Incidentally, their process was identical to the one utilized by the Bureau, except that low-cost coal instead of high-price coke was used for the heating agent. Their plant plainly disclosed that a minimum sales price around $300.00 per ton was necessary for continued operation. Such soaring markets did prevail as long as

the World War blockade was rigidly maintained. That high ceiling may never again be reached. Instead of the U.S.A. being dependent on foreign nations for 96% of its potash supply, it has already developed a sizable domestic industry. Its output has recently exceeded 50% of the national consumption. For further expansion in the new industry, no area offers more promise than the Green River locality. No further research work should be attempted in that sector except for the admitted object of setting the lower limit or floor price for potash production in the U.S.A. field.

The third and final process of the Bureau is a combined potash-phosphate smelting procedure that was designed for the production of 83% KPO_3. Its efficiency is rated on the previously inserted table at 47% as against 21% for their potash process, last reviewed.

This process produces a ton of high analysis fertilizer from only 9.33 tons of raw materials instead of the 24.5 tons required by the previously reviewed operation. The method is comparatively attractive, but its consumption factor is still considered too high for the operation of a commercial fertilizer industry in Wyoming.

An inspection of the comparative ratal tabulation on page 115 suffices to disclose a strong similarity to exist between the process of the Bureau and that of Mr. "X", previously reviewed. As the X report has already been quoted in full, no further reiteration need be filed herein on the Bureau's process.

Pike Process

The final listing on preceding tabulation is recorded as the Pike process. It calls for the annual production of 34,650 tons of potash (K_2O) and 57,700 tons of phosphate (P_2O_5) at a proposed plant to be erected at Green River, Wyoming. Annual output of the works would be marketed as 105,000 tons of potassium phosphate containing a guaranteed minimum of 92% KPO_3. The cost of manufacturing the above product is recorded at $3,782,500 annually. As stated previously these processes are patented by Robert D. Pike, a chemical engineer of 361 San Carlos St., Piedmont, California.

The 4 blast-furnace investigations previously summarized

were all performed by Federal research workers. An examination of their profoundly technical reports failed to spot a single idea that can be considered new to the chemical science. Obviously, such harmless conventionalities must be entirely free of advices for processing local rocks on a commercial basis.

The several reports of Mr. Pike belong to a different category. At plenty of places new and original methods are published for the first time. His suggestions should pave the way to the establishment of a sound and conservative fertilizer industry in the City of Green River at an early date.

All Federal investigators followed suite in regarding wyomingite as an ore of potash. In reality 90% of that material is nothing more than inert worthless rock. Regardless of that fact the cited research workers mixed their wyomingite with high grade phosphate rock in proportions sufficient to satisfy an orthodox chemical formula. No product of economic merit could be smelted for the admixture disparity of 10% potash rock and 30% phosphate rock required fluxing reagents of hitherto unprecedented volumes for the formation of a slag in the blast furnace. Far less formidable calculations are demanded by the Pike metallurgical operations. Only in the Pike process do phosphate rock and potash rock go into the furnace in the mutually fluxing ratio.

The Pike process is based on smelting a rock primary containing 78% or more tri-calcium phosphate. Preceding tabulation indicates that the Bureau of Chemistry had to use 0.99 ton of gravel with a 95% silica content to smelt a Tennessee rock of an equal degree of basicity. For their gravel, Pike substitutes wyomingite as the fluxing agent. As its silica content is nearer 58% after the potash is volatilized therefrom, it is accordingly necessary to use 1.60 tons of this less acid fluxing material for each ton of fertilizer produced.

At the furnace site gravel is already being washed and screened at a cost of not over 40 cents a ton. Pike's wyomingite flux would cost a $1.20 per ton delivered at the furnace hopper. Production capacity of the furnace has previously been rated at

100,000 tons of KPO_3 annually. Using gravel for the fluxing agent would reduce annual operating expenses by $152,000. Such a saving might not prove economical for the highly specialized site at Green River. From the wyomingite substitute flux no less than 16,566 tons of potash would be volatilized annually. The latter extra-recovery should sell around $993,960 in the open market.

Apparently, Green River is no longer just another town in which one type of fertilizer could be processed at a low cost. The vast Inter-Mountain phosphate province is full of such communities. The Pike substitute flux makes it possible to manufacture both types of fertilizer primaries at Green River. Only at that strategic site could the dual operation be conducted at almost as low a cost as single type fertilizers are processed at leading competitive points. The Pike million-dollar concept in extra recoverable values may soon rank among the great advancements in fertilizer manufacturing technique of the current century.

Supplemental Process

The Pike wyomingite flux yields only half of the potash required for a plant manufacturing 100,000 tons of potassium phosphate annually. The indicated deficiency of 18084 tons will likewise be supplied from wyomingite. The extraction calls for a supplemental process. Operating costs for the direct process proposed by Pike are far lower than those formulated by all prior investigators.

The recovery process proposed by Pike is based on the Lemberg reaction. One half the volume of the wyomingite rock is leucite. Under the Lemberg reaction that potash bearing mineral is converted into the sodium aluminum silicate mineral analcite through the exchange of the alkali base members. The economics and basic principles of the conversion have been set down by Pike as follows:

> "The present-day potential value of wyomingite, as a primary source of potash, depends upon the fact that each 100 pounds, when ground to only a very moderate fineness, quickly yields 8 pounds of K_2O by base exchange with sodium without the occurrence of side reactions, when leached under pressure at 200°C. Cheap and plentiful sodium compounds, particularly the carbonate, combined with cheap fuel will yield vast quantities of potash from wyomingite in the form of concentrated fertilizer chemicals at relatively low cost."

Preceding statement is based on experimentation in which 3 parts wyomingite and one part of salt were repeatedly cooked with 6 parts of water in a pressure vessel for a period of 3 hours. For the Pike process 744 tons of wyomingite would undergo the foregoing treatment each day. The operation would be conducted in large steel containers of dimensions tentatively approved in the Pike reports.

The feasibility of the preceding extraction has not yet been demonstrated on a semi-works basis. Pike's figures rest on over a 100 runs that he performed in a small autoclave having about the same dimensions of the less sturdy pressure cookers used by housewives. Satisfactory recoveries were yielded from these small tests. The repeated experiments, likewise, served to establish the non-corrosive character of the selected leaching solutions.

The prior flux volatilization process and the present supplemental lixiviation process were originated by Pike for the sole object of extracting potash from wyomingite at the lowest possible cost. A previously reviewed investigator smelted 10 tons of wyomingite with 14½ tons of fuels and fluxes to recover one ton of potash. His extremely expensive furnace charge originated from several states. For making up the potash deficit for a product equally valuable, Pike only needs to cook 3 tons of the local rock with 7 tons of soda brine water. The water supply would come from wells already drilled on the plant site. Obviously, the smelter method would involve purchase, labor, and transportation expenditures at least 7 times as great as the outlay required by the Pike proposal. A differential around 700% is also indicated in energy consumption. The wet process is conducted at 200°C. To smelt the rock it would be necessary to develop a temperature nearer 1400°.

Manufacturing Costs

All investigators so far cited have found only one value in the wyomingite deposits. It is their potash content which varies from 200 to 240 pounds per ton of rock. Potential value of latter material is only $6.00.

By unique methods patented by Pike it would be possible to extract the foregoing $6.00 value at a calculated expenditure of $3.29.

Such operations would actually show a profit. Other research workers devised schemes seemingly for the object of extracting $6 from a rock at a calculated cost as high as $24. Much of their enthusiasm could have been avoided. In fact their final results would have been less surprising had some one set down the value in the investigated rocks beforehand.

In his 1938 report, hereinafter referred to as Exhibit E, Pike estimated the cost of producing potassium phosphate in the Green River locality at $37.65 per ton. His figure compares favorably with the TVA cost of making ordinary phosphates at $30.54 per ton. See Exhibit A report.

The Pike product is the far more valuable of the two. It packs 41% more plant food than the TVA fertilizer. On a unit basis a saving of $5.41 per ton is indicated for purchasers of the more potent Pike concentrate.

Pike's cost analyses are based on the operation of a blast-furnace plant. Hereinbefore, the set-up at Green River has been held to be more adaptable for electric furnace processing. As soon as hydro energy is generated within that natural electrochemical basin, the Pike type of products ought to be processed as cheaply as the lower-grade phosphate fertilizers of Tennessee.

Four alternative flow sheets appear in Pike's latest 1938 report. They call for varying types of equipment. Only the least expensive of the Pike proposals is reviewed in this report. Cost of that plant is recorded at $12,668,700.00. Its annual sales return is set down at half of that figure, viz, $6,334,350.00.

Pike's investment figures doubtlessly err on the conservative side. His plant cost appears unreasonably high especially when it is compared to the published investments of competitive concerns. In Exhibit A, the cost of a works smelting 60% of Pike's phosphate production is recorded at only $2,270,000. Its capacity in annual sales is estimated at $2,056,000. To match that high degree of industrial performance, the initial cost of the big end of the Pike works would have to be scaled down to $3,750,000.

Less than 20% of the entire Pike output would be produced

by his wet supplemental process. He allows a $2,000,000 expenditure for that much less elaborate equipment. That estimate, likewise, appears unduly elevated. In fact, the weakest feature of the Pike proposals seems to be the excessively high cost allowed for initial plant construction.

This critical review is unprepared to sanction the construction of $12,000,000 fertilizer plants at any point in the country. At Green River a $6,000,000 plant having an annual sales capacity of $6,000,000 would offer far more attractions for investment. Manifestly, such a plant would have to be electrothermally operated. Its profits per dollar invested would greatly exceed those of a fuel fired plant that would cost twice as much to construct. Strongly entrenched vested interests will hardly regard Green River as the lowest cost site for processing fertilizers until the collateral hydro resources still remaining intact in that vicinity are adequately developed.

Federal and State Investigations

A survey of the phosphate resources of the Western fields is now being conducted by a Congressional Committee. Many proposals for the development of those vast deposits are already available for examination by the committee.

Before the current investigation started, several states had completed reports on their leading phosphate areas. Such investigations largely foreshadowed the drive now under way for the establishment of regional TVA's at different points within the Inter-Mountain phosphate province.

Unfortunately, the Western phosphates are quite analagous to those occurring in Tennessee. From identical material the TVA has already demonstrated that high-analysis phosphates could be processed therefrom by a low-cost electro-thermal method. In the average Western locality, no better or cheaper phosphates could be made than the grades already manufactured in Tennessee. Therefore, a second TVA establishment in an ordinary phosphate bearing area could only be looked upon as an unnecessary duplication of effort in the research field.

A mandate of Congress directs the TVA to improve, increase

and cheapen the production of fertilizers and fertilizer ingredients. Thus far TVA activities have been confined exclusively to phosphate production in which field industrial progress of basic importance has been consummated. If a second research plant is built, its operations might be limited to the investigation of potash, the other major mineral element consumed by plant life.

Basic problems solved 50 years ago by the phosphate industry still await solution in the National potash field. During the years of the World War potash prices suffered a 10-fold expansion owing to the inability of the domestic industry to supply over 4% of the National requirements. To release the industry from dominating foreign influences, steps should be taken to double domestic production at the earliest practical date.

Hereinbefore, plans for a plant capable of manufacturing 34,000 tons of by-product potash annually were briefly reviewed. That output would reduce potash importations into this country fully 15%. Such an operation would do its share towards transforming America into a completely self-sustaining unit in the industrial fertilizer field.

The TVA has been frequently censured for entering a branch of the fertilizer industry in which over-production evils commonly occur. Other critics maintain that the erection of a second plant in the Western phosphate fields might distress employment conditions in the older producing districts of the East. No like criticism has yet been advanced against the construction of a potash works at Green River. Apparently, an operation at that site would throw no one out of a job this side of Europe.

In times of business depression only one avenue of industry seems to be open to Governmental invasion and expansion. In the fertilizer field all manufacturing initiative ought to be limited to lines in which serious production deficiencies continue unmolestedly from year to year. Only such non-competitive ventures could prove 100% immune from intermeddling criticism. If the U.S.A. is ever to reach the status of a completely self-contained nation worthy of the name, it would seem immaterial ~~if~~ whether the requisite constructive effort was financed by public or private enterprise..

Summary

Many factors favor Green River as an industrial site for the manufacture of mineral fertilizer products. Several of the outstanding superiorities of the locality are listed below:

Huge deposits of minerals, chemicals and fuels suitable for the manufacture of all types of mineral fertilizers abound within the electrochemical basin at Green River, Wyoming.

A large outcrop of phosphate rock intersects the major hydro dam-site on Green River. At other proposed plant sites in the West the leading phosphate deposits are distant 500 miles or more from the nearest hydro dams. Such manufacturing procedures would involve power transmissions and raw material haulages far beyond the rules of recognized economic limits. If phosphate rock must be processed at the ultimate rock-bottom cost, it would be imperative to select the unique site that provides the complete assemblage at a single spot.

The nearest approach of the world's largest phosphate deposits to the markets of the Nation is at Green River. Thus far the local rocks have been successfully processed at only 2 points situated in Montana and British Columbia. For invading consuming outlets of appreciable magnitudes, a transportational differential of 500 miles or more would favor the phosphate processor at Green River, Wyoming.

So far only phosphate rock has been successfully processed within the vast Inter-Mountain province. Maximum plant food value in the present products shipped therefrom is not over 45%. At Green River both phosphate and potash rock would be compounded into a single product containing 90% or more in plant food value. Heretofore, only local markets have remained open for the low-grade phosphates processed in the Inter-Mountain province. To reach nation-wide markets the region must manufacture high-power fertilizers that contain nothing less than the standard of concentration predominating in the product from the Green River community.

Respectfully submitted,

Cheyenne, Wyo.
November 1, 1938

Report Enclosures

Exhibit A - Full-scale Production of Metaphosphate Achieved at Wilson Dam.

Exhibit B - Blast-Furnace Processes for the Production of Phosphatic and Potassic Fertilizer Materials.

Exhibit C - Volatilization of Phosphorus from Phosphate Rock.

Exhibit D - Proposed Manufacture of Monopotassium Phosphate at Green River, Wyo.

Exhibit E - Preliminary Economic Estimates for Production of Potassium Metaphosphate at Green River, Wyoming.

Exhibit F - Volatilization of Potash from Wyomingite.

Exhibit G - Smelting of Wyomingite and Phosphate Rock in the Blast Furnace.