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George H. Ashley, State Geologist.

SAND AND GRAVEL IN THE SCRANTON REGION, PENNSYLVANIA.

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Introduction.

In 1927 the Pennsylvania Geological Survey started an investigation of the sand and gravel resources of the State by sending the writer on a reconnaissance trip over the whole State. Nearly all the big centers were visited. The purpose of this trip was to find out (a) where the supplies of these materials were coming from, whether they were local or whether they were being shipped in, (b) whether the supplies, from whatever source, were satisfactory as to quality, (c) total quantities needed, (d) costs, freight rates, etc. The problem was approached from the commercial end, which meant interviewing operators of pits and quarries, contractors, dealers, and chambers of commerce. All of this was preliminary to detailed geological work which would be taken up in those regions least supplied, by nature, with these resources.

Scranton was one of the regions visited. It was found that the sand and gravel used came almost wholly from outside the district, much of it from as far as 90 miles distant.

In the summer of 1928 the writer undertook a geologic study of the Scranton region. The problem was to find, if possible, supplies of sand and gravel of sufficient size and proper quality near enough to Scranton to save the cost of long transportation. In six weeks the environs of the city were examined as were also the outlying localities 20 to 50 miles distant. The work was done mostly on foot, and with close enough detail so that some definite conclusions could be reached.

No attempt was made to locate all sand and gravel deposits regardless of size or quality. The problem involved finding deposits (a) of proper quality, (b) where there was opportunity for washing, for the trade, and especially the large contract, is demanding a uniform, washed product, (c) large enough to warrant putting money into a washing plant and other equipment, (d) near railroad or other trunk line of transportation. Trucking will pay (if roads are good) when distance is not over 10 miles, is doubtful between 10 and 15 miles, and unprofitable with greater distance. Of course, if the roads are good and one could get $4.00 a ton for delivery it would pay to haul by truck 25 or 30 miles. This is a rare case.

The results of this investigation are given in the following pages.

Uses and Specifications.

Sand and gravel are low-priced commodities. This does not mean that they are an insignificant part of our industrial world. They are necessities and the volume used speaks of their importance. Every moderately large community uses on the average one ton per capita per year. Scranton, then, with its outlying boroughs, needs, in round numbers, 200,000 tons of sand and gravel each year.

To make these materials better appreciated a brief list is given of the various uses to which they are put. These uses may be grouped in several ways, one of which is as follows:
Construction.

1. Making concrete - for highways, streets, sidewalks, buildings, blocks, fence posts, etc.
2. Mortar - for laying brick, stone, etc.
3. Plaster and finishing coats.
4. Asphalt paving.
5. Roofing.
6. Cushion sand - for laying paving brick, etc.
7. Road dressing - gravel alone; with binder for sand-clay roads; for oiled roads.
8. Railroad ballast.

abrasives.

10. Sand Blast.
12. Sawing stone.
14. Tumbling sand.

Manufacture (the main constituent).

15. Glass.
17. Silica brick.

Manufacture (as an accessory).

18. Foundry sand.
20. Pottery glaze.
22. Filler for fertilizer.
23. Sweeping compound.
24. Dusting tar paper.
25. Carborundum.

Miscellaneous.

27. Filters.
28. Engine sand.
29. Fire sand.
30. Standard sand.
31. Playground sand.
32. For golf courses.
33. On paint.
34. Bedding stock cars.
35. Sand flotation.
36. Horticultural purposes.
37. Agricultural testing.
38. Bird sand.

In a large community all of these uses will find a place, though naturally, as far as quantity is concerned, some are insignificant while others run into very large figures.

Specifications. Quite logically, one kind of sand will not do for all purposes. A sand that is too fine for concrete may be just the thing for asphalt pavement; a sand that would never serve for glass making may be entirely suitable for foundry purposes. The specifications or qualities required for each of the uses listed have been rather exactly determined, though authorities differ as to details. There is an extensive literature on the subject, which should be consulted by those who expect to be producers of these commodities. No attempt will be made here to discuss these specifications, but a partial list of the necessary qualities may make clearer the scope of the requirements.

In general sand and gravel should be clean, that is, free from loam and organic matter. The individual particles should be durable. Texture plays an important part: this refers to the sizes of the individual particles and the proportions of the various sizes present. Shape of particles is to be considered, too many flat
pieces are objectionable. Chemical composition is important only for a few of the uses, especially the high silica sands. Other properties that may enter into the qualities of food material are color, fusibility, permeability, sharpness of particles.

As an illustration of the thoroughness with which specifications are written the reader is referred to the specifications by the Pennsylvania Department of Highways (ask for Form 406) for sand and gravel used in concrete for roads, highways, curbs, etc. Or sand for Bulletin M 11 on Molding Sands issued by the State Geological Survey. Similarly each of the uses listed has its own literature.

Definitions of terms used in this report.

Texture.

Sand - grains less than 1/4 inch; may be coarse, medium, fine.
Fine gravel - 1/4 to 3/4 inch.
Gravel - 3/4 to 1 1/2 inch.
Coarse gravel - 1 1/2 to 6 inches.
Cobbles - 6 to 12 inches.
Boulders - greater than 12 inches.

Except in the case of sand, the natural deposits seldom contain one size only, as above defined. Rather, there is a mixture of several sizes. For field purposes the writer has somewhat arbitrarily used four classes.

Very coarse = Probably 50 per cent greater than 3 inches. Much coarse gravel. Considerable number of cobbles. Boulders always present. Sand content low.


Ordinary = Less than 20 per cent but more than 5 per cent over 3 inches. Moderate coarse gravel, Cobbles seldom present. Sand and fine gravel the dominant sizes.

Fine = Less than 5 per cent over 3 inches. Abundant sand.

This classification may not always give a true picture, for the simple reason that all the deposits are not seen to the same depth. So often the coarsest material is on top. In a ten or fifteen foot cut this is all that is visible; the finer sand below may more than equal the quantity above. The classification stands for the average texture of the exposure as seen, not as inferred.

Quantity. Since quantity is one of the requirements of the sand and gravel problem, the descriptive terms used must be given some exactness. They are based on the requirements for commercial plants. It will seldom be possible to get proper returns on capital invested in a washing plant and other equipment unless the operation is continued for at least ten years. On this basis the following terminology is used.
<table>
<thead>
<tr>
<th>Size</th>
<th>Tons per day</th>
<th>Reserves required, yards</th>
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<tbody>
<tr>
<td>Very large</td>
<td>1,000</td>
<td>2,000,000</td>
</tr>
<tr>
<td>Large</td>
<td>500</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Medium</td>
<td>200</td>
<td>400,000</td>
</tr>
<tr>
<td>Small</td>
<td>100</td>
<td>200,000</td>
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Experience shows that it is hardly practicable to set up a washing plant unless the output averages 100 tons per day.

This is not all the story. The quality of the materials must be considered as well as the quantity. There should be little or no appreciable waste. For instance, if there is little demand for gravel it will not pay to crush the oversize (greater than 3 inches). It must be noted, however, that if the oversize is durable it is more likely to pay to crush it, for the large gravel (1 to 2 3/4 inches) made of broken rock is more acceptable in specification work. Again, if there is little market for fine sand, a large percentage of this in a deposit is a drawback. Fine sand which is not wanted for concrete may, however, be used for mortar, finishing casts, asphalt, etc.

Present Sources.

Scranton has been getting, and still gets, practically its entire supply of sand and gravel outside the city limits. Fully 95 per cent is hauled from 25 to 90 miles by railroad. These materials cost at the operating plants all the way from 55 to 85 cents a ton. The freight ranges from 70 cents to $1.25 per ton. This puts them on the cars at Scranton for $1.60 to $1.85 per ton. The little that is brought in by trucks is delivered for $2.50 per ton usually. It is thus seen that the transportation charges make up the greater part of the cost of the product. One feature that increases the freight cost is the switching charge - so many different roads are tributary to Scranton.

The localities furnishing sand and gravel, with the distance of transportation, are as follows: New Jersey (Sussex County, etc.) 90 miles, Falls: 25, White Haven 54, Hancock, N.Y. 53, Lackawaxen 54, and New Milford 39. These are the most important sources, the first three probably furnishing something like 85 per cent of the total (this figure gives the order of magnitude and is not meant to be exact). The Jersey sand leads by a wide margin.

Other contributing localities are: Shickshinny 25 miles, Bangor 65, Avoca 8, and Moscow 14. Delivery from Avoca and Moscow is by truck.

The above data are shown graphically on the accompanying sketch map.

Detailed Studies.

The results of the 1928 field season will be described under three headings: (1) Lackawanna Valley, (2) Susquehanna Valley, and (3) Outlying districts.

Lackawanna Valley.

This valley naturally divides into three districts in each of which the sand and gravel deposits have certain common characteristics.
Scranton to Forrest City. One of the characteristics common to the deposits of this part of the valley is their coarse texture. The larger number of exposures seen would be classed as "very coarse" (see Definitions, page 4); most of the others would be classed as "coarse," while some are rated as "ordinary."

Another characteristic is that they all carry coal fragments, both in the coarser and finer materials. This is objectionable and prevents sale in all large and important contracts. Practically all the coal may be removed by thorough washing. The objection to coal is chiefly because it is not a strong and durable material. Also, the pieces of coal on surface work exposed to weathering will crumble and fall out, leaving the surface pitted. Coal may contain sulphur which will in time yield sulphuric acid. The color is objectionable for surface coats in some kinds of work. The to three percent of coal is allowed in specification sand for con-
crete work. This amount does not weaken the concrete, and the slight pitting that may develop on exposed surfaces is usually not objectionable.

A third characteristic is the limited size of most of the deposits. According to the classification (page 5) no deposit was seen that could be rated as "large," and only two rated as "medium." One of these latter is along the railroad tracks on the east side of the river just west of Winton. The other is about a mile north of Mayfield, on the east side of the railroad and road, were Powdorly Creek goes through. This latter one is doubtful; surface evidence on the continuity of the deposit is not convincing.

A word of caution must be introduced here. No test pits have been put down. So, unless a natural cut, well, or other information was at hand, the depth remained uncertain. The deposit north of Mayfield, for instance, may prove so shallow as to be rated as "small." These who may be interested in developing possible deposits should, of course, sink holes enough to determine accurately both the depth and quality.

Thus it will be seen that this part of the Lackawanna Valley probably can not be depended on to relieve the shortage at Scranton, because of lack of quantity in any single deposit.

Union Dale district. This northern part of Lackawanna Valley was visited not only to look for deposits of suitable size, but also because it is beyond the area of coal-bearing rocks. As one would expect, sand and gravel deposits in this district are free from coal.

The deposits occur along the East Branch of Lackawanna River less than half a mile south of the crossroad that runs from station to station. There is a smaller deposit about half a mile farther down the valley.

As to texture, the deposits seen are not as coarse as those found to the south. There is a moderate amount of oversize and a large quantity of sand. The deposits are variable, that is, there are rather rapid changes from sand to gravel or coarse gravel within short distances. This makes considerable selection necessary to supply local needs by the load, but would not matter if the whole deposit were washed and screened.

Because of the scarcity of open pits the size is uncertain. It would be rated from medium to large. Four or five test pits would prove the property.

Water for washing is plentiful, both from the river and from a creek that runs through the property.

The location is nearer the N. Y., O & W. R. R., which runs along the hillside well above the valley floor. It would require 500 to 600 yards of spur track unless small dump cars were run to a loading pocket directly on the railroad.

A deposit in this locality could serve several towns between Scranton and Union Dale; Carbondale especially would use a good quantity.

As a matter of caution it should be noted that there is a
water-supply lake about 1½ mile down stream. Most of the fines from washing would settle out within that distance, but possible contamination must be considered.

Scranton to Pittston. Between Scranton and Pittston the deposits as a whole do not have the very coarse texture to common above Scranton. While the material in some of the exposures would be rated as "coarse" there is none that is "very coarse." Some is "fine;" and like all the Lackawanna Valley (excepting Union Dale) coal fragments are always present.

As to size there is one very large deposit. This occurs in an irregular terrace on the west side of the river directly opposite Duryea. It reaches from track level to about 100 feet above the track. There are depressions and ravines within the terrace so it is not one solid mass 100 feet thick. On the other hand it may extend below the track level. A small creek will furnish some water for washing. The mine water from a coal mine shaft on the edge of the property is going to waste. Possibly this could be secured.

There is one large deposit. This is on the north edge of Pittston and extends from near the trolley line back to the silk mill on the hill. One large cut shows that considerable fine sand is present. Wash water seems limited unless ground water can be utilized.

Two medium to large deposits occur near together just west of Avoca along the Erie Railroad. Both appear to have a great deal of fine sand and will require considerable washing. No stream of clear water is immediately available.

A small to medium deposit is being worked by the B. and B. Sand and Gravel Company just north of Avoca, close to the Laurel line and near the Erie Railroad.

Northeast of Taylor and extending up the creek a short distance there are several deposits. Each one alone is small, but the combined total is large. They are knolls and ridges not closely enough connected to be worked by one plant, and besides they are in the midst of an active coal operating neighborhood. The water problem would not be easy.

As far as the Lackawanna Valley is considered, then, the favorable properties are narrowed down to Union Dale, near Tinton, near Avoca, north of Pittston, and across the river from Duryea. Of these the last mentioned is the largest and most favorable.

Susquehanna Valley.

The sand and gravel deposits along Susquehanna River between Falls and Shickshinny are quite in contrast to those in the Lackawanna Valley. They are free from or contain less coal, and several deposits are very large.

Pittston to Falls. This district extends from the mouth of Lackawanna River to two miles above Falls. None of the sand and gravel contains coal.

About two miles west of Falls a terrace deposit on the north bank about 80 feet above the river is operated by The Falls Sand and Gravel Co. They have a large pit and washing plant and are producing specification material. The reserves are large.
At Wyoanna a terrace deposit on the east side of the valley is being worked by the Wyoming Sand and Gravel Co. The reserves here are very large.

About half a mile up stream on another part of the same terrace is a deposit which it is reasonable to assume is quite similar to that at the Wyoming Sand and Gravel Co. pit, although evidence as to the quality and depth of the deposit is lacking. The area of the terrace indicates a very large deposit.

About three-quarters of a mile below Ransom, on the east side of the valley, is another terrace. A few 10 to 15 foot cuts show material similar to that in the commercial pits up stream. Assuming that the depth also is similar there is a large deposit of sand and gravel on this terrace. The Ransom Home with its grounds and fields occupies a large share of the northwest part of this terrace. If the deposit on this part of the terrace were available the reserves would be rated as very large. Two miles below Ransom on the opposite side of the river is an irregular terrace, the highest point of which is about 100 feet above the river flats. A pit with a 90-foot face supplied material for building the power plant directly opposite. It contains more coarse material (cobbles and some boulders) than the deposits up stream and would be rated at least as a large deposit. The most accessible means of transportation would be the branch railroad which extends up the river to the power plant.

In none of the above-mentioned localities has consideration been given to the valley flats which undoubtedly contain usable material.

At the Lehigh Valley Railroad yards between the tracks and the hill is a narrow terrace several hundred yards long. Cuts not more than 15 feet deep expose gravel containing a high percentage of over size, with cobbles rather common. The texture becomes finer with depth. The deposit is medium sized but the large amount of over size must be considered. A small reservoir occupies part of the space.

Undoubtedly there are other deposits up the river above the Falls Sand and Gravel Co. operation. Terraces above McHune presumably contain suitable sand and gravel in quantity, but the increase in freight rates up stream makes it inadvisable to consider deposits there for the Scranton market.

Pittston to Kingston. "Mountain Sands." At the base of the highlands on the northwest side of the valley and extending intermittently nearly the whole way from West Pittston to Toby Creek are deposits locally referred to as "mountain" sands or gravels. They occur on irregular, poorly marked high terraces up to 100 feet above the road that runs along the base of the "mountain." The position is similar to that of the deposit already described opposite Duryea in the Lackawanna Valley. All of these deposits contain coal, showing the influence of the Lackawanna drainage. They are being worked by various firms and individuals - Shoemaker Bros., Dunn, W. R. Ridgely, S. M. Durland Sand Co., E. W. Conley, J. P. Oshofski Sand Co., and others, none of whom have washing plants. The pits opened range from small ones with a 10 to 12 foot face to large ones with 30 to 50 foot faces. The texture on top is usually coarse or very coarse, but the exposures as a whole are ordinary in texture. A large proportion of medium sand is exceptional. The maximum thick-
ness may be well over 100 feet. Medium to large reserves occur in several places.

River flats and low terraces. By far the larger part of the sand and gravel deposits in this district are on the river flats and low terraces, extensive areas of which are as yet unimproved. Strange as it may seem, however, almost none of this material is being used. One would expect that the coal content would be very slight, for the moderate amount of coal-bearing sands from the Lackawanna drainage would be well diluted by the more extensive coal-free sands from the Susquehanna drainage. Furthermore, these are re-worked deposits. Two large pits below Forty Fort operated by H. D. Sordoni and F. Sgarlat, and one small pit (now abandoned) about a mile southwest of Wyoming confirm this analysis: they show only a trace of coal. These two large pits show an average ordinary texture which gets finer with depth. Fine sand and silt occur in spots. Test holes made in coal operations show a depth of 60 to 90 feet to bedrock. Very large reserves occur at several different places outside city limits. Railroads and water are near.

Shickshinny. Two miles below Shickshinny on the west side of the valley an extensive high terrace rises about 100 feet above the river flats. This high terrace has a maximum width of a quarter of a mile and extends along the valley side for fully three-quarters of a mile. Obviously there are very large reserves of sand and gravel here. This deposit is being worked by the Salem Sand and Gravel Co., directly on the highway and railroad opposite an electric power plant. The pit has an 85-foot face. The upper ten to twenty feet has a coarse to very coarse texture. Below is the usual ordinary texture. Exploration to a depth of fifty feet below the level of the road shows sand dominant. Coal is very noticeable, but washing removes practically all of it and makes specification material.

Other high terraces occur in this valley from Wilkes-Barre to well below Shickshinny, and doubtless contain material similar to the one described.

Outlying districts.

Smaller valleys, either tributary to the Lackawanna or entirely outside this system but within the distance limit required for supplying Scranton, contain deposits of sand and gravel. All of the promising ones along railroad lines were visited. The findings in these districts are presented below.

Spring Brook district. Up Spring Brook about two miles from Moosic is the remnant of a high terrace deposit. It is on the south side of the creek less than 100 yards from a branch of the Erie Railroad. An old pit with a 60-foot face shows the usual combination of coarse material on top and finer beneath. This deposit is nearly a quarter of a mile wide at the widest point and about 300 yards long. Estimate rates it as a large one. A small amount of coal is present. Water is available from Spring Brook, and from a small tributary that flows down a ravine at the west end of the terrace. Besides the Erie Railroad there is an old line running up the valley and with a spur to the pit. This line has not been used for many years and is not in good condition, but it would not be difficult to reshape it for use.
Within 2½ miles up the brook occur similar but smaller deposits and less accessible. The valley flats probably contain workable material.

Moscow district. Starting right opposite town at the mouth of the creek coming in from the east a series of deposits extends fully 1½ miles up the creek valley. They are on small knolls, ridges, and flats, no one of which is of any great size. Several pits operated intermittently by O. Noark, J. W. Swartz, E. Schinihoff, and E. Riesecker, produce unwashed material. The Noark pit was used by the State Highway Department in getting fine aggregate for the highway from Elmhurst to Gouldsboro. They put up a temporary washing plant. The deposits vary considerably from place to place, from fine sand to coarse gravel. The total of all the deposits is very large but it hardly can be rated as a site for large scale operations because the deposits are narrow and discontinuous. Probably half a mile of spur track would have to be laid. There is a small deposit a short distance up the creek that comes in from the south.

At Gouldsboro a small to medium deposit borders the east side of the track a short distance south of town.

Nicholson district. On Tunkhannock Creek where D. L. & W. R. R. crosses, and in part under the west end of the famous Tunkhannock Viaduct, is a series of gravelly knolls. Considerable sand and gravel must have been dug here for there are several old pits. These show about the usual combination of gravel, coarse gravel and sand. The deposits are not quite large enough to be rated as "small" unless the materials ten to fifteen feet below creek level are usable.

On the same side of the creek and about a quarter of a mile to the north is a terrace remnant with good material (Stevens pit). Here again the deposit is almost the size to be rated as "small" in our classification. A shallow well encountered quicksand below. If these two properties could be worked by one plant the quantity would be sufficient for a large scale operation. But there would be the difficulty of delivery to the D. L. & W. R. R. which, on the viaduct, is more than 200 feet above the creek. The Northern Electric R. R. is at road level but is about a quarter of a mile away.

About 2 miles south of Nicholson are several terrace remnants which have coarse gravel on top. An old pit has been worked intermittently by H. Chisholm for sand so it is assumed that the usual change of texture with depth occurs here also. If all the terrace remnants (which are not far apart) could be worked as one, a "small" property would result (greater if depth is generous). The distance (2 miles) from the D. L. & W. precludes putting in a spur track, but the Northern Electric is less than half a mile distant.

The Glenburn pit can be included in this district, though it is some miles to the east. The Edwards pit located right in the village is furnishing sand and gravel for local use. Another pit north of the village has furnished some. Both pits are in limited deposits and would not be considered for large scale operations.

Lake Ariel district. About 1½ miles from Lake Ariel towards Scranton on the Erie R. R. is the property being operated by Wayne Concrete and Sand Works. Knolls, flats, and hollows in a valley are composed of the usual assortment of sand, coarse gravel and some cobbles, plus an occasional very large boulder (5 to 10 feet). Exploration shows that sand, with very little gravel, occurs twenty feet below track level. A washing plant has produced specification
material. The deposit would be rated as medium to large.

Honesdale - Hawley district. The West Branch of Lackawaxen River within 4 miles above Honesdale has practically no deposits of sand and gravel; certainly none that are even of ordinary size. But deposits do occur on Dyberry Creek, which joins the Lackawaxen at Honesdale. F. J. Varcoe & Sons operate a pit on the north edge of town and there are others up stream. The nearest deposit is of no great size and to make large shipments from it would mean building a spur line nearly a mile long right through town.

In the next valley to the east there seems to be a supply of good material. Fred Knorr operates one pit. But the nearest deposit is a mile from the railroad and over a hill at that.

At Hawley, on southeast edge of town, is a pit operated by the Hawley Tile and Supply Co. The material is good but the deposit is not large enough for big operations, and is half a mile from the railroad.

At Lake Wallenpaupack, near the dam site, is a large pit that was opened to supply sand and gravel for the dam. It is good looking material, and reserves are large, but the deposit is 1\(\frac{1}{2}\) miles from the railroad. It is a question, too, whether the owners would allow further operation of this pit.

Along the railroad northwest of Hawley are three narrow sand-gravel ridges between the tracks and the valley sides. The one nearest to town (one end right in town) probably would rate small to medium in size. The next one, a little farther out, is not large enough, though it is above the ordinary size. The third one is about three-quarters of a mile out of Hawley. Though there are no good cuts along it, the surface material and the form both suggest a good deposit. In size it would be rated small to medium.

On the south edge of White Mills, where the railroad curves sharply, is an uneven terrace bordered by the tracks and rising as much as 50 feet above them. The materials are exposed only right along the tracks and that rather overgrown. Figuring on bulk alone the quantity would be rated as medium and may possibly be larger.

North of White Mills there are prominent valley flats. One place has a width of 300 yards along nearly half a mile of track. There are no holes or pits to tell of the quality or depth of the materials. As a typical valley fill it should contain an assortment of sand and gravel. Again, figuring on bulk alone and assuming but a moderate thickness the reserves would be large.

Between White Mills and Honesdale there are several other deposits on both sides of the river. One is right in East Honesdale. They are patches of terraces large enough for the usual local consumption but not of the dimension suitable for quantity shipment.

Stroudsburg district. Along the main line of the D. L. & W. R. R. northwest of Stroudsburg there are wide valley flats and terraces. These border the railroad for some two miles along Broadheads Creek and tributaries, and vary in width from a few hundred yards to at least a mile. Low knolls and ridges with bed rock cores interrupt this steady expanse of flat. Cuts along the railroad and highways show that these terraces and flats are composed of gravel.
and sand. The upper 10 to 15 feet is coarse gravel with some cobbles; below this the gravel decreases and the sand increases. The depth of the deposit could not be determined exactly. The deepest cut was 20 feet. The few wells in it penetrated 20 to 40 feet of the material. It is not unreasonable to assume that part of the deposit at least may be twice that thickness. Nearer town the area is improved property, but about a mile from the station (near the site of the International Boiler Works) the farm land begins. There are wide stretches of unoccupied territory adjoining the railroads that might be used for sand and gravel operations. The deposit should be rated as very large. Two streams would furnish water for washing, and ground water probably is within 15 feet of the surface on the flats and ten feet deeper on the terraces.

Summary.

Very large deposits. The reserves in six places are classified as very large. Two of these are being operated, Wyoming Sand and Gravel Co., at Wyoming, and the Salem Sand and Gravel Co., below Shickshinny. Very little from either plant is being shipped to Scranton. Salem Sand and Gravel Co. has an advantage in freight rates. This is the best source of a large quantity at reduced rate.

Of the other very large deposits not being worked, the most accessible one is the valley flat between West Pittston and Kingston. The others are at Stroudsburg, opposite Duryea, and just above Wyoming.

Large deposits. One of these is now being worked by Falls Sand and Gravel Co., north of Falls. The others, in their probable order of preference, are Spring Brook, flats north of White Mills, below Ransom, north edge of Pittston, at Fowler Station west side of river below Ransom.

Medium to large deposits. Of these the Wayne Concrete and Sand Works is operating one near Lake Ariel. Of the others probably the "mountain" sands and gravels near Wyoming would be first choice; these are being worked to some extent but not washed. A deposit at Union Dale is in this class and two deposits west of Avoca are possibilities.

Others. The medium and small deposits are less attractive to the large operator just because of their size. Two of them have additional drawbacks because the necessary railroad spur would be long and not easily placed. If one does not want to operate in a large way good material may be secured from many of the small deposits already described, as well as still smaller ones not included in this report.

The freight problem. As has been stated already, the transportation is the largest part of the cost of sand and gravel. Furthermore, the freight rates are not simply a matter of distance. Nor is the rate proportional to the distance; for instance, the freight rate from Avoca (3 miles) is the same as from Shickshinny (25 miles) and Hancock (53 miles). The switching charges are another item of expense. A load of sand coming into Scranton on the D. L. & W., say, for delivery to a customer whose spur track is on the Erie R.R., may be subject to a switching charge of three cents per hundred pounds. It may thus cost as much to deliver a carload of sand within the city as it does to haul the carload to the city. Delivery in this case does not mean putting the sand on the job, but
only on the track of the contractor who orders the sand. The fact that so many railroads are tributary to Scranton makes switching a rather formidable part of the total cost. The sand and gravel operator will do well to secure customers whose receiving spur is on the same line as his shipping railroad. It is possible that both the freight rates and the shipping charges may be reduced by some concerted action on the part of the sand and gravel users.

Origin.

Sand and gravel is deposited through the activities of water. Heavy rains washing down a slope commonly move much loose material into the smaller streams, often leaving scars or gullies to show where the material was secured. Smaller streams in turn tend to pass on their load to the larger ones, adding material that they have gouged out by their own action. When rivers are high and active they are turbid because of this mud and sand carried in suspension. If their velocities are great they can and do sweep along large quantities of gravel, coarse gravel, or even boulders. Indeed the velocity determines much of the two processes of wearing away the land (erosion) to get the load and the carrying of this load afterwards. The volume, of course, also determines very largely the total work done.

What may be called the reverse of the process may take place anywhere down stream, under the proper conditions. Since velocity determines so largely the getting and carrying of the load, it follows that with decreased velocity (after the load is secured) some or all of the load must be dropped (deposited). The larger fragments naturally are dropped first and the smaller ones later. In this way the materials are sorted, resulting in an accumulation of alternating layers of sand, gravel, etc., as the velocity diminishes or increases. Besides the sorting and laying of the material in beds another thing must happen. The fragments themselves become worn by the friction among themselves during transportation. Their sharp edges and corners wear off and they may become well rounded if the journey is long enough. Whether the fragments have a certain color, or are durable, or have a certain composition depends on the slopes and ledges which furnished the materials for the streams in the first place. For instance, since coal outcrops on the slopes of the Lackawanna Valley it is natural to expect coal fragments in the sand and gravels derived from these slopes.

So it is that knowledge of the origin of sand and gravel gives one an understanding and appreciation of the qualities they possess and why they have such qualities.

Naturally the interest centers in the process of deposition, for until the gravels and sands are concentrated in one place by deposition they are of little use to the operator. In looking for deposits of sand and gravel one would logically look in those places where water can run or where it has run in the past, in small and large valleys, lake beds, etc. Valleys that had considerable depth in the past may now be filled up to the level of the depositing streams. Such valley fill accounts for the flat floors so often seen. And these fills may be 30 to 100 or more feet deep. Still another thing may happen. If the stream changes its habits after filling a valley it may begin to erode this filling and eventually establish its flow at a lower level. In doing this it may take out all of the original fill down to the new level of flow, but it usually leaves some of it still in place. These remnants of the older fill standing well above the present stream are called terraces.
They are a common source of our sand and gravel supplies.

Why streams should vary in velocity, volume, and load, and hence in the deposits made, depends upon a variety of conditions. Each year we have our wet and dry seasons, our times of freshet and low water. Larger changes must have occurred in the past, judging from the large deposits, high terraces, etc. Among several causes the most apparent single one is tied up with the glacial history of the northern United States. The immense ice cap that slowly moved down from Canada loosened unusual quantities of rock debris by its gouging and scraping. When the ice melted there was an unusual quantity of water released. An unusual quantity of loose rock material with an unusual quantity of running water to erode and carry it gives ideal conditions for large scale deposits farther down along the drainage lines. Apparently that is what happened with the forming of fill 50 to 200 feet deep in many of the valleys. With the final retreat of the glacier the unusual conditions were gone. The streams, not being furnished with such great loads of material and possibly influenced also by changing gradients, began to erode instead of deposit, with the result that the fill was in part removed, the portions not removed remaining as terraces today. Other evidences of the glacier's presence in this region are the parallel grooves and scratches found in so many places on the surface of the bed rock. One good place to see this phenomenon is in May Aug Park, Scranton, on the east side of Lake Lincoln.