ANNUAL REPORT

OF THE

STATE GEOLOGIST

OF

NEW JERSEY,

FOR 1869.

TRENTON, N. J.:
PRINTED AT THE TRUE AMERICAN OFFICE.
1870.

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GEOLOGICAL SURVEY OF NEW JERSEY.

To His Excellency, Theodore F. Randolph, Governor of the State of New Jersey, and President of the Board of Managers of the State Geological Survey:

SIR:—I have the honor herewith to submit my annual report, on the work of the Geological Survey, for the year 1869.

With high respect and esteem,

Yours truly,

GEO. H. COOK,

State Geologist.

RUTGERS COLLEGE,
New Brunswick, Dec. 28, 1869.

REPORT.

DISTRIBUTION OF THE GEOLOGY OF NEW JERSEY.

At the date of the last report, the Geology of New Jersey with the accompanying maps was passing through the press. Two thousand copies of the work were printed, and of these one thousand copies were bound. Since then five hundred more have been bound. The remainder are still in sheets. One thousand copies of the accompanying maps were colored and put up in portfolios, and the engraved stones were kept for further use. Since that time five hundred additional sets of the maps have been printed and prepared for distribution.

A large Geological Map of New Jersey on a scale of two miles to one inch, was also prepared, and two hundred copies were printed and colored. One hundred of these have been backed and mounted and the second hundred must soon be prepared, as the first is nearly gone.

According to your instructions, copies of the Geology and Maps have been given to various public officers and institutions, and others have been sold at the cost of paper, printing and binding. The price in this way put upon the book was very low, so low indeed that it left nothing to cover the cost of selling, and, of course, no inducement for booksellers to engage in its sale. The explanation you gave for this very low price, viz: that it saved from any invidious distinctions in distributing a few copies among the many who might desire it, and also placed it at a cost so moderate that any who choose could buy it, appears to be entirely satisfactory. There is no trouble in selling out the entire edition to booksellers, who would then be able to put it at a price which would pay them a profit. As the results of the Survey are intended for the benefit of the people of the State, it is undoubtedly best to continue the books at the same price as heretofore, for some time to come. It may be desirable to put them in the hands of booksellers, and raise the selling price, after the offer of them at the present rates has been continued for a sufficient time. The prices at which they have been sold are given in the accompanying descriptive list:

Geology of New Jersey, 899 pages large octavo, illustrated by 103 photolithographic engravings and woodcuts, and six mine maps; and accompanied by a portfolio containing the following maps, in sheets:

1. Azoic and Paleozoic Formations, including the Iron-ore and Limestone districts; colored. Scale 2 miles to an inch.

2. Triassic Formation, including the Red Sandstone and Trap-rocks of Central New Jersey; colored. Scale 2 miles to an inch.

3. Cretaceous Formation, including the Greensand Marl Beds; colored. Scale 2 miles to an inch.

4. Tertiary and Recent Formations of Southern New Jersey; colored. Scale 2 miles to an inch.

5. Map of a Group of Iron Mines in Morris county; printed in two colors. Scale 3 inches to 1 mile.

6. Map of the Ringwood Iron Mines; printed in two colors. Scale 8 inches to 1 mile.

7. Map of the Oxford Furnace Iron-ore Veins; colored. Scale 8 inches to 1 mile.

8. Map of the Zinc Mines, Sussex county; colored. Scale 8 inches to 1 mile.

Price of the book and portfolio of maps, $6.00.

Geology of New Jersey, as above, without portfolio of maps, but containing a folded and colored map of the State, on a scale of 5 miles to 1 inch. Price $4.00.

Single copies of either of the above maps, colored and in sheets, 50 cents.

Geological Map of New Jersey, on a scale of 2 miles to one inch; colored and mounted on rollers. It gives the Geology of the State the same as Maps 1, 2, 3, 4, in the portfolio, and is essentially these combined in one map. Size 5½ by 7½ feet. Price $8.00 per copy.

The prices are fixed to merely cover the cost of paper, printing and binding; the expenses of the Survey and preparing book and engravings being paid by the State.

These publications can be had from Prof. Geo. H. Cook, State Geologist, New Brunswick, on remitting the price, or through the booksellers.

The books are also kept for sale at these prices by William T. Nicholson, of Trenton; Sampson & Morgan, of New Brunswick; M. R. Dennis & Co., of Newark, and D. Van Nostrand, of New York city.

The work is in the following public libraries, where it can be consulted:

In all the State libraries; in some other of the large public libraries in different parts of the United States, and in the following libraries in New Jersey and in the adjacent cities of New York and Philadelphia, viz:

New Jersey State Normal School;
New Jersey Model School;
Farnum Preparatory School;
West Jersey Academy;
Pennington Seminary;
Drew Seminary;
Newark High School;
Newark Academy;
Rutgers College;
Burlington College;
Princeton College;
Princeton Theological Seminary;
Theological Seminary of Reformed Church;
New Jersey Historical Society;
Seton Hall;
Newark Library;
Burlington County Lyceum;
Winslow Lyceum;
Camden Library;
Salem Library;
Dennis Library at Newton;
Tuckerton Library;
Millville Library;
Bricksburg Library;
Yardleyville Library;
Burlington Library;
Rancocas Library;
Woodbury Library;
Young Men's Christian Association of Trenton;
Young Men's Christian Association of New Brunswick;

Young Men's Christian Association of Hackettstown;
Young Men's Christian Association of Jersey City;
Home for Disabled Soldiers;
Home for Soldiers' Children;
American Iron and Steel Association, Philadelphia;
Philadelphia Library;
American Philosophical Society, Philadelphia;
Academy of Natural Sciences, Philadelphia;
New York Historical Society:
Astor Library, New York;
Mercantile Library, New York;
Cooper Union Library, New York;
Mechanics' and Tradesmen's Library, New York;
New York Lyceum of Natural History;
American Institute, New York;
American Geographical and Statistical Society, New York;
Long Island Historical Society, Brooklyn;
University of New York;
Columbia College, New York.

A copy of the Geology and two of the large mounted maps, were also offered to each of the County Clerks for deposit in their offices; one of the maps to be hung in the court room, and the other in the Clerk's office. Under this offer the book and maps have been sent to the counties of

Atlantic,	Mercer,
Bergen,	Middlesex,
Burlington,	Morris,
Camden,	Passaic,
Cape May,	Somerset,
Cumberland,	Union,
Gloucester,	Warren,

And they will be sent to

Essex,
Hudson,
Hunterdon,
Sussex,
Monmouth,
Ocean,
Salem,

on application from the County Clerk.

It has also been supplied to the following Farmers' Clubs for their Libraries:

Progressive Farmers' Club, Mt. Laurel;
Vineland Agricultural Society;
Somerset County Farmers' Club;
Seaville Farmers' Club;
Union County Farmers' Club.

And it will be furnished to any others in the State, which give promise of permanency, on their application.

It is desirable that every public library in the State should have a copy of the work, and it will be forwarded on application from the *proper* authority;

EXPENSES.

The expenses of the survey for the year have been $3,977.14, a sum considerably within the amount appropriated.

CONTINUATION OF THE SURVEY.

In accordance with the provisions of the law of last winter (1869,) the survey is continued.

The State Geologist appointed in the original law of 1864, continues his supervision of the survey. The Assistant Geologist, Professor J. C. Smock, is for the present, detached from the work, to extend his knowledge of

Geology and Metallurgy, by study and travel in Europe. It is expected that the survey will have the benefit of his studies and experience in preparing the report on the Iron and Zinc Ores.

Edwin H. Bogardus, the chemist of the survey, has been steadily engaged in the laboratory. He has completed the analysis of a large number of soils, in preparation for that part of the work, and has in addition analysed many fertilizers, clays, marls, &c., and is making experiments on the chemical changes that take place in various composts and rotting manures.

Edward A. Bowser, a graduate of our State Agricultural College, has been employed since the middle of September in a survey of the Newark and Elizabeth undrained marshes, and the reclaimed marshes of Salem, and a survey of Passaic river, with its branches, the Whippany and Rockaway, above Little Falls.

PLAN OF THE WORK.

The chief operations of the Geologist and his assistants, will be directed to putting the results of the survey in form for practical use. In carrying out this leading idea the investigations and conclusions will be arranged and published under the following general heads.

1. *Fertilizers found in the State, and the means of making them more quickly and generally useful.*

Under this head will come the results of those inquiries, investigations and experiments, which are so much needed for our advancing agriculture. The State has inexhaustible supplies of phosphatic and calcareous marls, of rich alluvial and marine deposits, and of fish and other fertilizers from the sea and its bays, sounds and creeks, which our farmers should know how to use at the earliest possible time, and in the most economical way. There is also an enormous waste of fertilizers in our towns and cities, which can be saved with great benefit, to both public health and agricultural productiveness.

2. *On the Marshes, and Tracts of Land subject to Protracted Freshets.*

There is a large area of land of this kind in the State, the improvement of which is demanded by the public interests. It is held in small tracts, so that the owners are not in power to carry out plans for its drainage; and information regarding its formation and condition, its capabilities and the means for its reclamation, is of large and general importance.

3. *On the Soils of the State, their origin, chemical and physical properties, distribution, and suggestions for their most productive management.*

With a full third of the State unimproved, and in condition to be successfully treated, by the intelligent use of capital, it is plain that this subject should be made a matter of scientific investigation.

4. *On the Iron and Zinc Ores of the State.*

In the *Geology of New Jersey* this subject is taken up in connection with the rock formations of the State. The origin of these ores, the chemical changes they have undergone, their rock and mineral associations, the geological changes to which they have been subjected, their present occurrence, and the modes of searching for, and of mining, are all treated of in that work, but under different general heads. They deserve a distinct and separate examination and description.

5. *Additions to the Scientific and Economical Geology of the State.*

Every year is adding to the stock of knowledge upon these topics, and it is of importance to have this knowledge made public as extensively and as early as possible.

I. FERTILIZERS FOUND IN THE STATE, AND THE MEANS OF MAKING THEM MORE QUICKLY AND GENERALLY USEFUL.

The mineral and other fertilizers found in the State have been described in much detail in the Geology of New Jersey, and in the Annual Reports of the Agricultural College. I present here some analyses of Greensand Marl, and tables for their valuation as fertilizers:

ANALYSES.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Phosphoric Acid	1.14	3.58	2.58	3.87	1.33	1.02	2.30	2.24	2.69	2.56
Sulphuric Acid	0.14	0.97	1.89	.31	.00	.27	.00	.39	.26	0.22
Silicic Acid	38.70	53.15	59.80	54.75	46.03	50.23	57.67	50.80	49 40	51.50
Carbonic Acid	6.13	......	......	......	......	......	......	......	......	.....
Potash	3.65	3.75	4.25	4.11	5.67	6.32	3.53	5.18	6.31	4.62
Lime	9.07	3.27	2.97	5.46	2.01	1.40	1.26	2.13	2.52	1.26
Magnesia	1.50	1.75	2.06	2.99	3.47	3.45	3.67	3.54	3.24	3.95
Alumina	10.20	8.79	6.00	6.46	7.86	7.94	10.10	8.77	8.90	6.01
Oxide of Iron	18.63	15.94	11.98	15.20	25.23	20.14	14.16	17.63	17.11	21 04
Water	10.00	8.98	8.32	6.85	8.40	9.00	7.25	9.66	9.10	7.39
	99.16	100.18	99.79	100.00	100.00	99.77	100.00	100.34	99.53	98 55

(1) Is an average of the variety of marl most largely used in eastern Monmouth. It is not particularly rich in phosphoric acid, but is remarkable for containing from 10 to 20 per cent. of carbonate of lime in fine powder. In the neighborhood of this marl where it costs little more than the cartage, a great deal is used, which is much poorer than this; but there is no trouble in finding millions of tons of this quality. It is used in larger quantities per acre than the other varieties, and is remakable for the permanent improvement it makes in the soil.

(2) Is an average of five analyses of the *Squankum* marl, and may be taken as a fair sample of that noted fertilizer. The specimens for analysis were taken from five different pits, and each was judged to be an average of the whole digging.

(3) Is an average of the marl dug by the Squankum Marl Company. It is supplied of this quality along the entire line af the Raritan and Delaware Bay Railroad, and also at Port Monmouth for shipping. This marl is dug from the green and ash layers of the upper marl bed. The ash marl is more clayey and poorer than the green marl. But the mixture of the two is a good fertilizer, as both experience and the analysis show.

(4) Is an analysis of an average sample taken from a pile of 100 tons of marl sent by the Freehold and Squankum Marl Company to New Brunswick. A sample carefully averaged by my assistant, Mr. Bogardus, at the pits of the Company, yielded $4\frac{58}{100}$ per cent. of phosphoric acid.

(5) Is from the pits of the Cream Ridge Marl Company. The analysis is from an average specimen taken at the pits by my assistant, Mr. E. H. Bogardus.

(6) Is from the pits of the Pemberton Marl Company.

It was from a sample prepared by J. C. Gaskill, Superintendent, and was averaged by cutting an uniform slice from the top to the bottom of the bank of marl, and carefully mixing the whole.

(7) Is an analysis from the pits of the Vincentown Marl Company. The sample I believe to be a fair average.

(8) Is an analysis of marl dug at White Horse, on the line of the Camden and Atlantic Railroad. An abundant supply of this marl is to be had; and it is the source from which it can be easiest sent to all of Atlantic county, and the country along the Camden and Atlantic Railroad.

(9) Is the analysis of a carefully averaged sample of marl from the West Jersey Marl Company's pits at Barnsboro'. Several hundred tons of it are sent over the West Jersey Railroad every day, to supply the wants of farmers in the country traversed by that road and its branches. The growing demand for this marl is the best proof of its good quality. It is from the green layer of the middle marl bed.

(10) Is an analysis of an average sample of marl from the pits of Dickinson Brothers, at Woodstown. This marl has an excellent reputation. From 10,000 to 15,000 tons are sold annually to the neighboring farmers, and hauled away in wagons.

Tables for Calculating the Value of Marl, and for Comparing it with other Fertilizers.

TABLE I.

Stockhardt's Table of the gold values of the chief elements in fertilizers, copied from Caldwell's Agricultural Chemical Analysis.

Form in which the substance exists in the fertilizer.	PRICE PER LB. IN GOLD.
Phosphoric Acid, soluble in water as in super phosphate,	$ .12½
Phosphoric Acid in Peruvian guano,	.10
Phosphoric Acid in steamed bones finely ground, in rape cake, poudrette, etc.,	.08½
Phosphoric Acid in Baker guano,	.07½
Phosphoric Acid in coarse bone-meal, fresh human urine, etc.,	.07
Phosphoric Acid in coarse broken bones, fresh human excrements, stable manure, etc.,	.05½
Potash as potassic sulphate,	.06½
Potash as potassic chloride and in other forms,	.05½
Nitrogen easily soluble, or in compounds that are readily decomposed, as in ammonia nitrate, dried blood, meat, urea, etc.,	.22
Nitrogen in finest bone-meal, poudrette, etc.,	.19½
Nitrogen in coarse bone-meal, rape-meal, horn-meal, wood-dust, fresh human urine, etc.,	.16½
Nitrogen in coarse broken bones, horn shavings, woolen rags, fresh human excrements, stable manure, etc.,	.13¾

TABLE II.

The English valuation of these substances is given in Vol. 20, p. 74 of the *Country Gentleman*, by Dr. Voelcker, Consulting Chemist to the Royal Agricultural Society of England. It is as follows, allowing two cents for each English penny :

1. Nitrogen in the form of ammonia,	16	cts. ℔ lb
2. Nitrogen in animal or vegetable substances,	12	"
3. Nitrate of Soda,	4	"
4. Phosphate of Lime, (bone earth),	2	"
or Phosphoric Acid alone,	4	"

		PRICE PER LB IN GOLD.
5.	Soluble Phosphate of Lime, or Bi-Phosphate of Lime,	9 cts. ℔ lb
6.	Salts of Potash,	2½ "
7.	Gypsum.	2 cts. ℔ 10 lb
8.	Lime,	2 " 12 "
9.	Carbonate of Lime,	2 " 25 "
10.	Magnesia,	2 " 10 "
11.	Organic matter, (humus),	2 " 20 "
12.	Common Salt	2 " 10 "

PRICES BY PROF. JOHNSON.

Professor S. W. Johnson, of New Haven, Connecticut, in a report to the Secretary of the State Board of Agriculture on Commercial Manures, made last winter, estimates the gold value of potash, at 4 cents a pound; soluble phosphoric acid at 12½ cents; insoluble phosphoric acid 4½ cents, and nitrogen 17 cents. Professor Johnson is the best authority on this subject, in our country.

By the use of these tables the approximate value of the marls may be calculated.

The phosphoric acid is combined mostly with lime, though a little of it is probably combined with oxide of iron. The phosphates of lime and iron are both in very fine powder, or else in soft grains, so that while it cannot be quite as soluble as superphosphate, it is certainly much more soluble than any bone-dust. Judging from Stockhart's table of prices and qualities of fertilizers, I think the phosphoric acid in our marl should be rated between that in guano, which is 10 cents a pound, and that in steamed bones, which is 8¼ cents, and therefore propose for it in our calculations, 9 *cents gold as the price per pound.* The potash in the marls is combined with silicic acid, and the compound, silicate of potash, is not readily soluble in water. Johnson's price, 4 cents a pound, is for soluble potash as it is found in carbonate of potash (pearl-ash,) sulphate of potash, muriate of potash (chloride of potassium,) or crude potash, The potash in the marls is, however, dissolved out slowly by the action of water containing carbonic acid, and so becomes available. Until there is some more decided reason for fixing a different price, I will set down its value at 2 cents a pound.

The value of the several marls given in the above table would then be easily made. Considering the phosphoric acid and potash as the only parts of the marl worth transportation, their values range from $3.50 to $8.50 a ton; and I believe, that in comparison with the prices paid for concentrated manures, they are worth that price to the farmer. The cost must be taken when they are upon the soil, and not, as might be thought, when in store. I am confirmed in my opinion of their value by the testimony of successful farmers, who have used them for twenty years or more; and who assure me, they can better afford to incur an expense from $5 to $8 a ton, than to farm without them or to use any other purchased fertilizers; and also confirmed by my own observation in all parts of New Jersey where marl has been used. It gives lasting fertility to the soil. While all other fertilizers are exhausted and the soils become poor, I have to see the first field that has ever been well marled that is now poor. One instance was found where poor and sandy land was marled more than thirty years ago, and has ever since been tilled without manure, and not well managed, which is still in good condition. Occasionally marled fields are seen that do not grow crops as large as they once did, but all their fertility is immediately restored by a dressing of lime ; an effect which could not have been produced by the lime on unmarled land.

I am averse to having the valuation on the various green sand marls which are used in the State, based on the phosphoric acid and potash only in the above table of analyses ; for I do not think they are the only useful substances in it. The fine carbonate of lime in No. 1, is certainly of too much value to be neglected. And the sulphate of lime (gypsum) in many of them is enough to be very beneficial to crops. The valuation, however, seems to be demanded, and this is the best approximation I can make.

Table showing the estimated value of the Phos[illegible] Acid and Potash in the ten samples of Marl anal[illegible].—Marl contains no Ammonia.

No	Phosphoric Acid.			Potash.			Total Value per ton
	Per cent.	Per Ton. Pounds.	Per Ton. Value.	Per cent.	Per Ton. Pounds.	Per Ton. Value.	
1	1.14	22.8	$2 05	3.65	73.0	$1 46	$3 51
2	3.58	71.6	6 44	3.75	75.0	1 50	7 94
3	2.59	51.6	4 64	4.25	85.0	1 70	6 34
4	3.87	77.4	6 96	4.11	82.2	1 64	8 60
5	1.33	26 6	2 39	5.67	113.4	2 27	4 66
6	1 02	20.4	1 83	6.32	126.4	2 53	4 36
7	2.33	46.6	4 19	3.53	70.6	1 41	5 60
8	2.24	44.8	4 03	5.18	103.6	2 07	6 10
9	2.69	53.8	4 84	6.31	126.2	2 52	7 36
10	2.56	51.2	4 60	4.62	92.4	1 85	6 45

Other Fertilizers in Comparison.

An average sample of *Peruvian Guano* may have its value calculated in the same way, and if we use Johnson's prices, considering also 14 cents for ammonia to be equal to 17 cents for nitrog n, and the phosphoric acid as equal to soluble, the result is:

For 15 per cent. ammonia, or 300 pounds per ton,	$42 00
For 5 per cent. potash, or 100 pounds per ton,	4 00
For 10 per cent. phos. acid, or 200 pounds per ton,	25 00
Total gold value for one ton, ...	$71 00

A first quality Super-Phosphate.

For 7. per cent. Ammonia, or 140 lbs per ton,	$19 60
For 6.5 per cent. Soluble Phos. Acid, or 130 lbs. per ton.	16 25
For 5. per cent. Insoluble Phos. Acid, or 100 lbs. per ton, ...	4 50
Total gold value per ton.	$40 35

Pure Raw Bone.

For 5 per cent. of Ammonia, 100 lbs. per ton,	$14 00
For 25 per cent. of Insoluble Phos. Acid, 500 lbs. per ton, ...	22 50
Total gold value per ton, ...	$36 50

Marl, and by this term I always mean greensand marl, unless it is otherwise expressed, is a mineral substance and not very easily or rapidly dissolved, and it does not appear to have any unusual power of absorbing ammonia. As part of the value of a fertilizer depends upon its solubility, it becomes of prime importance to the farmer to quicken the solubility of marl as much as possible. Composts of marl with lime, or barn-yard manure or guano, produce this effect, and where the experiment has been thoroughly tested by farmers, it has proved highly satisfactory.

Experiments are in progress to determine the chemical effects produced upon marl by composting, and some advance has been made; but the results are not yet complete enough for publication. Experiments and inquiries are also in progress, to see if any process can be devised for separating the phosphoric acid and potash from the mass of the marl, and so put in a more concentrated form for transportation to distant places, at less cost.

II. ON MARSHES AND TRACTS OF LAND SUBJECT TO PROTRACTED FRESHETS.

The marshes along the sea-shore, and tidal waters of the State, cover a large extent of surface. Nearly all of them are only waste ground, unproductive, unsightly, and directly under the eye of the public. These marshes, if reclaimed, would be the most productive farm lands in the State; and the location of some of them in the immediate vicinity of New York City, where land is high priced, is creating a necessity for their entire reclamation at an early day.

It is remarkable that these marshes should have so long remained unimproved, when the success and value of such improvements were so well understood. Marshes in the vicinity of Salem were dyked and drained as early as the year 1700, and from that time to the present, such works have been continued, and profitably managed in that part of the State. To those engaged in the Geological Survey, the contrast between the rich and productive lands in the dyked grounds of West Jersey, and the waste and forbidding wild marshes of East Jersey, was very striking and suggestive. We cannot do better than to reprint here, an extract from the Geological Report of 1866, upon this subject. The successful improvement of the tide-marshes has been effected by shutting out the flow of the tide by embankments, and allowing the drainage to go on through sluices open only at low-water. By this means they are made dry, nearly to low-water mark. This work of banking in meadows has gone forward till the territory rescued from the sea amounts to 15,000 acres in Salem county alone besides large areas in Gloucester, Cumberland and Cape May counties. The largest tracts, and perhaps the most successfully managed, are in Salem county. The work has all been done by private enterprise; the owners of a tract that could be profitably enclosed by a single bank, associating themselves together, and carrying the work forward under the terms of the banked-meadow law.

For the improvement of such a tract it is necessary to get the consent of the owners of two-thirds of the acres included in it, before the work can be begun. The ground is then surveyed, the banks located, and the courses of ditches and streams arranged by disinterested parties, or commissioners, who are generally men of large experience in the system of meadow drainage. The first operation is to dig on the site of the proposed bank a trench four feet wide and two spits deep. By this means the sod and grass roots of the surface are removed, and there is a firm foundation made on which to raise the proposed bank. Then a ditch twelve feet wide and three spits deep is dug outside the trench, and on the side next the creek or other body of water. This supplies the material for the bank. The spits thrown out of the ditch are cut into small pieces, and fitted tightly together in the bank by the packer, just as stone are laid up in a wall. This mud when well packed, forms a very strong and durable bank so long as it is kept moist. If it gets too dry the bank will crumble down. But this is rarely the case, since the flood tides generally keep the banks on the outside quite moist, and even wet. The general size of the Salem banks is four feet high above the meadow, eight feet wide at the bottom, and three feet on the top. The slope is commonly one-half to one on the inside, and nearly one to one on the outside. Exposed situations require larger and stronger banks, as, for example, those on the wearing or concave shores of streams, or where there is danger of high tides, from wind and water conspiring together. Thus at Finn's Point, on the Delaware, in Lower Penns Neck, where there is a very exposed shore for two or three miles along the river, the bank is ten feet high, twelve feet wide on top, and thirty feet at the bottom. The top is wide enough for a wagon road. The mud bank is also protected by a facing of stone on the river side, which secures the whole against any dangers from washing by heavy waves and high tides. By this bank an area of 1,200 acres has been safely protected at an unusually exposed point. In Cumberland county the banks range from three to seven feet high, and are built immediately on the surface af the meadow.

The banks are built at a little distance from the edge of the stream, leaving a strip of marsh outside a rod or more in width, for the protection of the bank and also for supplying the mud used in repairing. This space is called the *guard* or *shore.*

The cost of banking meadow varies greatly. Those built of mud from a ditch twelve feet wide and three feet deep, formerly cost $1 a linear rod; now they cost about $3 per rod. The banking of Fishing Island meadow, Lower Penns Neck, cost $10 an acre. Another tract brought in, in 1866, cost $15 an acre. The first is about the present average cost. Along Maurice river banking now costs $2 a linear rod, and upwards. These estimates by the acre include the whole expense of cutting drains and water-courses, in addition to the building of banks. For the proper drainage of the meadows, ditches are cut at intervals, varying with the needs of the meadow. These are generally seven feet wide and two feet deep. When they are intended as boundaries, they must be nine feet wide, or no suit for trespass can be maintained. Wide drains with sloping sides are found the best for securing complete drainage. Such meadows need constant attention, and require annually considerable outlay of capital for the necessary repairs of banks and drains, and improvements of the surface. The expense of their maintenance in good order, varies much with the degree of exposure. Generally the cost for repairs ranges from fifty cents to $1 an acre, yearly. The Finn's Point meadow costs on an average $2 an acre per year. Much of the expense is caused by the depredations of the musk-rat which burrows into and through the banks, rendering them peculiarly subject to breaks by high water. The ravages of these animals are met only at an enormous expense every year. To avoid as much as possible injuries from these pests, it is considered advisable to examine the banks at frequent intervals, and to dig out any holes found in them. This work is expensive, as it can only go on at low-water. Some companies employ a man one day each week to examine the banks and note the points needing immediate attention, thereby preventing breaks in the banks, which are so apt to occur where the muskrat has been at work. Another source of danger to the banks is the perforations of the soldier crab or *fidler*. These are very numerous, and their borings into the bank sometimes make it into a complete sieve, through which the water strains upon the meadows. Constant watching is required to prevent their damages. Besides these living enemies the meadow owner also has to contend against breaks from high tides, and from settling of banks. Nearly all banks require occasional additions to the top caused by crumbling of mud, or more frequently by the settling of the whole bank. Where they are built upon firm mud, as is commonly the case along streams, the amount of settling is very little, but where they cross a meadow, or form what is called a *cross-bank*, or run across an old water course, the settling is an item of much labor and expense. Some are known to have sunk down as much as ten feet in the same number of years. The cross-banks are more liable to settle, because of the thinness of firm mud covering the peaty mass beneath. Wherever built upon such peaty substratum, settling is inevitable, and continues until a solid bottom is reached. The settling is generally gradual, but instances are given, in which the bank has gone down at once out of sight. As long as tide-marshes are open, liable to be overflowed at high-water, and so kept soaked full, they remain nearly at the level of high-tide; but after banking and draining they become quite dry, and the spongy mass slowly decays, and is consolidated, thereby causing a sinking of the whole surface. Tillage hastens this subsidence by opening the mass to the action of atmospheric agencies, and by a large annual withdrawal in the form of crops. From these causes a slow and gradual settling is effected. In nearly all banked meadows the difference in heights of the outside *guard* and the enclosed meadow, is very perceptible. The constant silting of fine sediment upon the areas outside the banks, often brings them nearly up to the height of the projecting bank. And after a long series of years of cropping, the meadow settles down to low-water mark, and it becomes unprofitable for further cultivation, on account of imperfect drainage. To remedy this the banks are opened at several points, and the muddy water allowed to enter and deposit its sediment upon the surface. The thickness of this deposit varies exceedingly, some streams depositing much more than others in the same time. Maurice river and Salem creek carry down a large amount of mud, while Alloways creek deposits a mere film on the surface in one season. The meadows are left open to tide water for a period of from five to ten years, according to the rapidity of deposit. A meadow near the city of Salem which has been open to the tide for ten years has now a mud deposit covering it to an average depth of two feet. By this covering of mud the meadows are raised so as to be drained with more ease, and their quality is much improved; the grasses also are much more nutritious. This operation really covers the meadow with a new soil, and one of lasting fertility. Some meadows settle so little that they have been tilled regularly for the last seventy years, and it is said that on some the banks have been in repair for over a century. These are exceptional cases, however. To open the banks require the consent of the owners of three-fourths of the included acres.

Another mode of counteracting the settling, and also of improving the meadow, is to allow the tides to enter during the winter, by opening the sluices. In this way a layer of muddy sediment is deposited all over the surface, which may vary from a mere film to twelve inches in thickness in one winter. The best and most practical meadow managers prefer this winter flooding of their meadows, as an improvement and counteraction of settling. By this mode there is no loss of the crops for five or ten years, which necessarily occurs when the banks are not closed. Others think that flooding is altogether useless; lime and superphosphates improve them, and there is no need of a a fresh covering of sediment. But as the subsidence is certain wherever there is a peaty substratum of much thickness, flooding must be adopted, or else occasional dressings of marl or upland earth will be needed to keep up the height of surface above low-water mark. The frequent application of soil from the adjacent upland would also be a cheap and valuable amendment to these meadows, which contain an excess of vegetable matter.

These meadows are composed of earthy or vegetable matter, all of which has the common designation of *mud*. *Blue* and *grey* mud is a deposit of clayey substance, and is blue when wet, and grey when dry and weathered. *Black* mud is fine muck, or disintegrated vegetable matter, *Horse-dung* mu d or turf, is the fibrous and peaty matter that constitutes the spongy part of the marsh, and is nothing but a net-work of grass and sedge roots. In most of the meadows the blue mud rests upon the peaty mud. The grey mud is most abundant near the banks of streams. It would seem as if the blue and grey mud deposits of this region are of recent origin; as late as the settlement of the country and clearing of the forests. Streams now hold in suspension a much greater amount of mud than when the country was covered with woods.

The banked meadows of Salem and Cumberland are the very best of grazing lands, and furnish indirectly a vast amount of manure for the uplands. The lowest of them grow herds grass, which is raised for seed. Salem is the great centre of the trade in this product, for our whole country. The average yield is about thirty bushels to the acre, and a common price for it is seventy-five cents a bushel. The stalks though not as good as hay, are valuable for fodder and litter. The care and expense of such lands is but very little, so that the crop may be considered a profitable one. The meadows along Maurice river are found suitable for the growth of timothy and grain and root crops, and enormous crops of these are grown from year to year without any manure. At Finns Point the yield of wheat is from thirty to forty bushels per acre; and of potatoes, from 150 to 200 bushels. The blue and grey mud soils are always good for any crop whatever. The black mud is not reliable for wheat, but Indian corn thrives on it. Lime acts like a charm on meadow everywhere. It is common to use it in dressings of 100 bushels an acre, with good effect; and there is one authentic case of 900 bushels having been used on one-third of an acre, and a large crop of corn being raised on it the same season.

The value of the banked meadows in Salem may average $100 an acre, some being worth $400 or $500, and others considerably less. On the Cohansey and Maurice rivers they are much more valuable than the adjoining upland, ranging in price from $50 to $200 an acre. Before they were banked these marshes were almost worthless. They yielded at the best salt grass or sedge, which may be used as a coarse fodder or for packing. In Lower Alloways creek, Salem county, salt marsh bordering the Delaware is worth from $1 to $5 an acre. About Leesburg, Cumberland county, it sells for from $10 to $20 an acre. The common opinion among meadow men is, that all marsh which can be made to grow herds grass can be profitably banked where the cost of banking does not exceed $15 an acre. In short, all meadow or salt marsh that can be drained by open ditches, may be reclaimed with profit; and if it is two feet above low-water mark that is generally practicable. Where water is quite salt, as is the case near the ocean or mouth of the bay, the meadow will need two or three years to get freshened enough to grow anything except salt grass. Time will, however, in nearly all cases after banking, bring about such a change that herds grass may be raised, if not timothy and the clovers. The great point is to get drainage; the tides can be shut out no matter how high they rise. The question then is, how much is the marsh surface above low water? and if not too low, banking is both practicable and profitable.

The following is a tabular statement, by counties, of the number of acres of tide meadows, fresh and salt, in the State:

Counties.	Number of Acres.
Bergen,	11,910
Hudson	12,896

Counties.	Number of Acres.
Essex,	4,282
Union,	4,445
Middlesex,	7,335
Monmouth,	5,958
Ocean,	31,155
Burlington,	25,429
Atlantic,	38,003
Cape May,	58,824
Cumberland,	51,078
Salem,	28,602
Gloucester,	9,958
Camden,	3,652
Mercer,	1,946
Total,	295,474

Of this great extent of marsh, only about 20,000 acres are inclosed by dykes, nearly all of which is along Delaware river and bay. The remaining 270,000 acres are still comparatively unimproved, and worthless for real agricultural purposes.

There are many of the salt marshes which contain too little earthy matter to be very solid, and the tide-water which flows over them is so free of sediment, that none is deposited. When the improvement of these is undertaken they will be found to sink to low-water mark very soon, and if the drainage is continued it can only be done by pumping, or otherwise lifting the water above tide-level, a work which has not been done in this country, but which experience in foreign countries shows to be both practicable and profitable. Holland, which has an area of near 12,000 square miles, has between 6,000 and

8,000 square miles of its surface included within banks or dykes, and it is kept dry enough for cultivation by raising all the water that gets on it from rain, springs and leakage, by pumps, to the height of five, ten, fifteen and in some extreme cases twenty-two feet. The land thus reclaimed is among the most productive in the world. The course of improvement began there just as it is beginning here. At first the marshes were dyked in, and drained by sluices, but as they sank away, it was found necessary to continue the work by draining the water down to a lower level, and then raising it in pumps by the force of wind, and so allowing the settling to go on until the marshes had become solid ground. In addition to the marshes, they have drained in the same way ninety lakes, the last of which, Harlem Lake, covered an area of 45,000 acres, and was, on the average, over twelve feet deep. This immense work required the raising of 1,000,000,000 tons of water, which was done in about four years, at a cost of $3,592,537, or not far from $80 an acre. The first sales of land in it brought $100 an acre, and it is expected that the whole amount of sales will equal the original cost. The annual drainage will require the raising of 54,000,000 tons of water.

On the north and northeast sides of England, there are immense tracts of reclaimed lands. The "Great Bedford Level," includes an area of 680,000 acres of the best land in England, which has been converted by drainage from a dreary waste into a fruitful plain. These lands are too low to be drained by sluices at low-water, and resort is had to pumps, driven formerly by wind-mills, but now chiefly by steam. The drainage is done effectually, and the power required to do it has been carefully calculated.

The rain fall there is twenty-six inches a year, or a little more than two inches à month. This is 7,260 cubic feet on an acre, and can be raised ten feet high in two hours and ten minutes by the power of one horse, or one horse power engine would drain 332 acres. Coleman says "that two steam engines, one of sixty and the other of eighty horse power, are effectual to the draining of 40,-000 acres of what is called the *Deeping Fen.* The upper part of these lands, which are thus drained, was peat meadow, the lower part was salt marsh. These lands are now in the highest degree productive, yielding fine crops of wheat, oats, potatoes and swedes, besides furnishing the very best of pasturage and hay lands. There is found to be a difference in the qualities of the grass; the lowest land are fed with sheep, and the highest with cattle. Barley is not cultivated on these lands, but besides the crops above mentioned, mustard, wood and chicory are extensively cultivated. Four crops of wheat in succession have been taken from these lands without manure. As the last crop was less than the former, the land was then laid down to grass. The rent of these lands is $8.55 and $9.00 per acre, but this must be considered as a moderate rent for lands so valuable. By means of these steam engines, the water is kept down to the required level. It is not found necessary to work them at all times, and the power is sufficient for any extraordinary emergency.

"A tract of about 6,000 acres in Nottinghamshire, on the Northern boundary of this county, called *The Carrs,* has been drained in a similar way. The general impression is that the sea once flowed over this territory. Half a century ago this morass was first attempted to be brought into cultivation. At that time it was absolutely a bog, and no horse could be used in ploughing it. The first attempts at draining it were not successful. In 1828 a steam engine of forty horse power was erected at a cost of $30,000 for lifting the water by a wheel. The engine is placed upon the main drain, at about three-quarters of a mile from the river Trent, into which the drainage of these Carrs empties itself; but unfortunately when high tide flowed up that river, there was frequent interruption to the drainage from the water in the river being higher than that in the drain, and it would have flowed in upon the Carrs had not flood gates prevented it. By placing the engine at some distance from the Trent, a reservoir was then formed in the main drain, within that space planked by high banks, and so by lifting the water into this reservoir to a higher level than the Trent, it is enabl[illegible] to fall into that river at all times.

The wheel for lifting the water revolves between two st[illegible] walls, in a space about twenty-seven inches wide, t[illegible]h which the whole of the water is driven. The wheel itself is formed of cast metal sides, with wooden paddles between, placed ingeniously at a certain angle, which enables the wheel to lift the water above its own centre; thus a wheel of thirty-three feet diameter creates an artificial drainage equal to more than its radius of sixteen and a half feet. Flood gates are again placed immediately before the wheel, to prevent the water coming back on the wheel ceasing to revolve. Absolute command of the water is now effected, and a provision has been made of incalculable value to the occupiers of these Carrs, by introducing during the summer months, water from the adjoining river Idle, as a supply for the stock. The total cost of two engines for the purpose of this drainage, has been little less than 60,000 dollars, and the annual expenditure of working the engines and cleansing the drains is from sixty-seven to ninety cents an acre."

Our marsh lands are as susceptible of improvement, and as productive when in cultivation, as those of England or Holland—and they are so near the great markets of our country that their improvement is a matter of necessity.

It would undoubtedly cost more labor to drain our marshes by pumping, than it does in England or Holland. Our annual fall of rain in New Jersey averages forty-five inches in depth, with an extreme variation, in different years, of nine or ten inches above or below the average. The annual rain-fall on the east coast of England averages twenty-six inches, and that of Holland thirty inches a year. These figures will enable any one who may desire to compute the amount of work needed to drain an acre, and to estimate its cost.

The New Jersey Land Reclamation Company have purchased and inclosed with a dyke the whole tongue of marsh at the head of Newark Bay between the Passaic and Hackensack rivers, and extending up from the Bay to Saw Mill Creek, covering an area of 6,000 acres. The tide is now effectually shut out, and the water in the ditches stands very nearly down to low water mark. To protect the bank from the ravages of muskrats they put in it a core of thin cast-iron plates, which reach from a foot and a half above the surface to three and a half feet below. They have faced the exposed parts of the bank with stone, are cutting out and opening the ditches and drains, and have already plowed several hundred acres. The energy with which the company is prosecuting this enterprise is in the highest degree commendable, and the successful prosecution and completion of such a work in this place will do more for such improvement than it could anywhere else on the continent. They richly deserve all the advantages their admirably selected location can give them.

The cost of building dikes is likely to be materially lessened by the use of labor-saving machinery. Several banks have been built in Salem county within the last year or two, by the use of a steam dredging machine. It does work at a very moderate price, and in the place where I saw it operating, which was on the bank of Salem creek, in Lower Penns Neck, on Mr. Howard Sinnickson's meadow, it was doing work which could not have been done at all by hand labor, and was building a substantial bank at a cost not greater than that of any other good bank.

The success which has followed the banking of meadows in West Jersey, and the little progress made in such work in East Jersey, has led to the inquiry whether there is any reason for this difference on account of difference in the condition or quality of the marshes on the two sides of the State. To answer this inquiry, Edward A. Bowser, a competent surveyor and observer, was sent to sound, survey, and note the peculiarities of material in the marshes along the Hackensack and Passaic rivers and Newark Bay, and then for the comparison, to do a like work upon the banked meadows along the Delaware and its branches in Salem county. This survey has been completed, and maps of the marshes and meadows have been drawn out by Mr. Bowser. His report to me upon the subject is inserted here, and his maps are appended. I need only say in regard to it that the difficulties encountered in Salem have been much greater than need be expected in the marshes of East Jersey, and that the quality of material for soil does not appear to be any better.

Report of the Tide Marsh on Newark Bay and the Passaic and Hackensack Rivers.

"The accompanying map of the above named marsh represents the *nature* of the surface material and its *depth.* The sounding was done with a slender iron rod, in the months of September and October, when the marsh was tolerably dry. In most places the material was very firm, requiring all the strength of *one* man, and sometimes of *two*, to put the rod down to the bottom. Especially was this the case where the material was blue clay or mud.

On the map the small figures denote the depths of the soundings down to a firm gravel, or sand bottom. The *short, straight, horizontal lines* represent blue clay; the *curved* lines represent peat or muck, which is simply peat or vegetable matter more or less decomposed; a mixture of *straight* and *curved* lines represent blue clay and peat, sometimes mixed, and at other times one overlying the other. The other signs used are explained on the maps.

By referring to the map it will be seen that the marsh between Elizabeth and Newark is mostly blue mud (clay) varying from seven to sixteen feet deep. The bottom is firm gravel. Near the upland, for a long distance, the clay is mixed with peat, and in some places as the Central railroad and near the New Jersey railroad on the northern edge of the marsh, it is all peat. The soundings in the peat and clay vary between three and eight feet.

Between the Passaic and Hackensack rivers, and south of the Morris canal, it is all blue clay and very firm, varying between eight and eighteen feet deep. It has a bottom of gravel.

Between the Morris canal and the New Jersey railroad, the map shows that on the Passaic side it is all blue clay, while on the Hackensack river it is blue clay and peat mixed, and up near the railroad and intermediate between the rivers, is the southern edge of an extensive cedar swamp. This blue clay is eighteen feet deep in some places, while the clay and peat mixed is not over twelve feet deep. Near the meeting of the railroad and the Hackensack river it is all *clay* again, and continues on up beyond the Morris and Essex railroad, varying from twelve to upwards of twenty-four feet deep.

North of the New Jersey railroad is a cedar swamp bottom, which extends from the Hackensack river to the upland, on both sides of the Belleville turnpike, and a narrow strip runs north nearly to Berry's creek. In this swamp the stumps in many places are so thick that it is difficult to run a rod down. The soundings vary from three to eight feet, with a sandy bottom. On the edge of this swamp the material is clay and peat mixed, which on the west side extends to the upland, and a little north of the New York and Erie railway. Between this cedar swamp and the Hackensack river it is blue clay, in some places twenty-three feet deep, and extends, with the exception of a little cedar swamp near the upland and the Paterson plank road, up to Hackensack city.

On the east side of the Hackensack river, with the exception of a small area just north of the Paterson plank road, and near the Northern railroad, which is clay and peat mixed, it is all blue clay, very firm, and in some places over twenty-four feet deep.

The marsh bounded by the Morris canal, Hackensack river, Saw Mill creek, and the upland on the west, is dyked in. This takes in most of the cedar swamps. All the rest of this tract of marsh is out to the tide.

Report on the Marsh on the Deleware, in Salem County.

The map of the marsh on the Delaware river and Salem, Alloways, Hope and Stowe creeks, represents the *nature* and *depth* of the surface material, the markings used being the same as those on the map of the Newark marshes.

The map shows that on Salem creek there is much more blue clay than peat. In many places the two are mixed, sometimes there will be a few feet of clay on the surface, while all under it is peat. This is the case on Fisher's Island, which has lately been dyked in. On the surface is blue clay, about four feet deep, after this it is peat, and in many places over thirty-six feet deep. In some places on Salem creek soundings fifty feet in depth failed to strike bottom.

On the Delaware river, north of Salem creek, the clay and peat surfaces are in patches, the latter much exceeding the former in area. The marsh is not so deep as on Salem creek. On the Delaware river, between Elsinboro' Point and Alloways creek, the marsh is mostly peat, and varies from four to sixteen feet deep.

On Alloways creek the material is clay towards the head of the creek, and clay and peat mixed towards the mouth, and varying from eleven to thirty feet deep. On Stowe creek the material is mostly clay and peat mixed, in many places over thirty-seven feet deep. On Hope creek the material is either peat alone or peat mixed with clay, the depth varying between five and twenty feet.

It is exceedingly difficult to describe localities, on a plain like the marsh, on either of these maps. A reference to the figured depths, and the conventional markings on the maps, will give a clearer idea of their features and substance, than any description in words can possibly convey."

It should be observed that these maps, besides presenting a comparison between the marshes on the Delaware and those on Newark Bay, also furnish important information upon which to base plans for their reclamation, and by showing the material of which they are composed, they show the culture to which they are adapted, and the treatment they need to make them productive for general farm culture. It is an easy matter to make the blue clay deposits into the richest of farm lands as soon as they are well drained, but the peaty soils require much more skill and labor to bring them into the best state of cultivation.

The Wet Lands on the Passaic River and its Branches, the Rockaway and Whippany, above Little Falls.

The country inclosed between the Highland range of mountains, and the curved trap ridges called the First and Second Mountains, being a part of the counties of Somerset, Union, Morris and Essex, is not well drained. The Passaic river, with its branches, flows across the district in crooked channels and with sluggish current, and finally escapes from the basin by falling over a depression in the Second Mountain at Little Falls. The rocky substance of the Mount forms a natural dam, which effectually holds the river in check. So flat is the valley that in freshets the river, which is thus dammed, overflows its banks for more than twenty miles up the stream, and lays thousands of acres of land under water. The current in the river is so feeble that the freshets subside with extreme slowness, and it has frequently been the case that the entire crop on these flowed lands has been lost, and the accumulation of stagnant water has caused fever and ague to become severe and wide-spread. The damages from spoiled crops, loss of labor, injury to stock, &c., could not have been less than $100,000 in 1867. The occupants of the land in this district have been contending with this difficulty ever since the country was settled; the channels of the streams have been cleared of obstructions, ditches have been dug across the flat grounds, large expenditures of time and money have been made. But it has not been at all alleviated. It is to-day worse than it was fifty years ago.

The water power at Little Falls has been part used for many years. A log on the reef, or a light wooden dam below. which raised the water to near the level of the reef, has sufficed to turn the water off to the mill. During the present year a substantial stone dam has replaced the former wooden one. The owners of the flowed lands have always looked upon this dam with a jealous eye, lest it might in some way increase the trouble the reef itself gave them.

The lack of drainage, and the losses attending it, are apparent; the damage to public health is proved by the mournful experience of many, and the great importance to the State of having this beautiful valley fitted to receive those who would delight to make it their home, if its salubrity were established, is becoming plainer every day. In view of these facts, and desiring to carry our work to practical ends, I have had levels run and soundings made along the Passaic from Little Falls to Chatham, and up the Rockaway and Whippany to the end of the flat grounds. The results of the survey are put down in the accompanying detailed map, profile and statement of distances, levels, and depths of water, as they were taken by Mr. Bowser. He says "the heights along the *surface* were found by leveling from the benches established by Geo. W. Howell, C. E., in 1868. The position of the *bottom* was determined by sounding in the channels of ie rivers, and subtracting the depths from the heights of e surface. In the table the top of Beatty's Dam, at ttle Falls, is the datum plane. The heights of the ints both along the surface and the bottom of the river, re measured from this plane; those points which are below the level of the dam having a minus (—) sign before the numbers.

By an examination of this table, as well as by an inoection of the profile, it will be seen:

1st. That the bed of the Passaic, from Little Falls up Horse Neck Bridge, which is $9\frac{65}{100}$ miles, is almost all elow the level of the dam. Even in the dryest season ie water in this part of the river must stand in many laces eight, ten and even twelve feet deep, as there is no vay for it to escape, except by evaporation, the bed of the iver being so much below the level of the dam.

2nd. That the top of the reef 347 yards above the 'am is twenty inches lower than the top of the dam; nd the reef alone would dam the water nearly back to Horse Neck Bridge, making it six and eight feet deep in many places.

3rd. That the bar of boulders and earth at Two

Bridges being but two-tenths of a foot below the top of the dam, must be a great obstruction. Even if the dam and the trap reef were both taken away, this bar would dam the water back to Horse Neck Bridge, making it several feet deep. All the work of throwing trees and roots out of the river between Two Bridges and Horse Neck Bridge, while these obstructions remain below, is so much time and labor lost One might as well throw trees and stones out of a mill-pond to make the water run, while there is a good tight dam backing it up.

4th. That from the bed of the river at Lower Chatham Bridge to the top of Beatty's Dam, distant twenty-one and three-quarter miles, there is a fall of only $6\frac{3}{10}$ feet, or less than three and-a-half inches per mile. If this bottom slope from this bridge to the top of the dam were uniform, this fall would do very well for a large river like the Mississippi, but for a small stream like the Passaic it would give but a very sluggish current. A fall of three and-a-half inches per mile will give the Mississippi, down towards its mouth, a velocity of over six feet a second, whereas the same fall would not make the Passaic, above Little Falls, run one foot a second.

By applying the *New Formula* deduced by Captain Humphrey and Lieutenant Abbott in their investigations on the Mississippi—a formula applicable to the smallest streams and the largest rivers—by applying this formula to the Passaic, we find that a fall of seven and a half inches per mile will give it a velocity between one and a half and two feet a second, even with the present very crooked channel. This fall can be obtained by cutting the dam down seven feet. The trap reef will have to be cut down five and three-tenths feet. A small reef sixteen yards above the dam will require lowering three and a half feet. From this point, up the river to Chatham, the present river bottom is low enough for the increased slope, with the exception of the bar at Two Bridges, and some insignificant bars at one or two other places; and the scouring action of the water, if the current were increased would probably soon regulate these.

A reference to the profile shows the new or proposed grade with a fall of seven and a half inches per mile—and it is seen that the present bed of the Whippany is above this, so that a small amount of work upon it would give a fall of from one and a half to two feet per mile, which will be sufficient to drain the adjacent lands as deep as is desirable."

There are many curious and interesting facts regarding this stream, and its deep channel, and the influence of obstructions in it—but it is not desirable to draw attention from the main point which is that *for any effective system of drainage for this valley the first step is to remove the obstructions at Little Falls.* Anything short of this will be incomplete, and temporary in its effect.

The advantages to be gained are very great. There are 11.400 acres in the townships of Caldwell, Livingston, Hanover and Chatham which are liable to be damaged by freshets, and there is an area of seventy-five square miles, or nearly 50,000 acres which is more or less affected by this insufficient drainage, and caused to be of questionable salubrity. It would be a small estimate to put an additional value of ten dollars an acre upon this whole valley on account of this improvement, if the land were to be used for farming purposes only, but when it is considered that the land is located within an hour's ride of

New York City, and can be made most desirable for the homes of men doing business in the city, its additional value must be greatly increased. Neither does it follow, if this improvement is carried out that the water-power at Little Falls must be all destroyed; or the benefits which come from such an important manufacturing village be lost. Of the thirty-four feet fall, only the upper fourteen feet are used, and then but half of the water which flows in the stream. Under these circumstances it is surely possible to preserve the valuable mill-privileges of the Falls and yet make this needed improvement.

The valley of the Passaic above Chatham, is also suffering from obstructed drainage, and very great injury is being done both to agriculture and to public health in consequence. The Great Swamp in Morris and Passaic townships is almost a waste from the same cause—and like the others, its improvement would bring a large addition of taxable property to the state, and be of benefit to the community.

The people of Orange county, in New York, have made a vigorous attempt to remove the obstructions in the Wallkill, at the lower end of the Drowned Lands. The successful accomplishment of this work will be very beneficial to a large body of land owners in Sussex county, and it is to be hoped that it will be effectually carried out.

There is a much needed improvement of the same kind to be made in draining the Long Meadow on the Pequest, in Warren county.

The agricultural wealth of the State, as well as the health of our town and suburban districts, is so largely dependent on thorough drainage that it seems appropriate to copy here the conclusions upon this subject which were long since settled by the British Board of Health, and which are now everywhere accepted and are copied in all our books upon drainage.

The following are the chief agricultural advantages of land drainage to individual occupiers or owners:

"1. By removing that excess of moisture which prevents the permeation of the soil by air, and obstructs the free assimilation of nourishing matter by the plants.

"2. By facilitating the absorption of manure by the soil, and so diminishing its loss by surface evaporation and by being washed away during heavy rains.

"3. By preventing the lowering of the temperature and the chilling of the vegetation, diminishing the effect of solar warmth not on the surface merely, but at the depth occupied by the roots of plants.

"4. By removing obstructions to the free working of the land, arising from the surface being at certain times from excess of moisture, too soft to be worked upon, and liable to be poached by cattle.

"5. By preventing injuries to cattle or other stock, corresponding to the effects produced on human beings by marsh miasma, chills, and colds, inducing a general low state of health, and in extreme cases the rot or typhus.

"6. By diminishing damp at the foundations of houses, cattle sheds, and farm steadings, which causes their decay and dilapidation as well as discomfort and disease to inmates and cattle."

"The sanitary interests, also, of a locality urgently demand attention to the drainage of its land; for excess of moisture most powerfully influences the local climate, both as to dryness and temperature, as shown in the report of the Metropolitan Sanitary Commissioners, under the following heads:

"1. Excess of moisture, even on lands not evidently wet, is a cause of fogs and damps.

"2. Dampness serves as the medium of conveyance for any decomposing matter that may be evolved, and adds to the injurious effects of such matter in the air; in other words, the excess of moisture may be said to increase or aggravate atmospheric impurity.

"3. The evaporation of the surplus moisture lowers temperature, produces chills, and creates or aggravates the sudden and injurious changes or fluctuations of temperature, by which health is injured.

"Note.—A farmer being asked the effect on temperature of some new drainage works, replied that all he knew was, that before the drainage he could never go out at night without a great-coat, and that now he could, so that he considered it made the difference of a great-coat to him."

The outlet for drainage water is a most essential part of any system of works, and being generally outside the lands to be drained, is a matter of difficult adjustment, in apportioning its expense. The difficulties, however, should not hinder their being made, for, quoting again from the same authority: "Whatever amount of money may be spent for relief by drainage, or however skillfully drainage works may be constructed, the money and the labor will be thrown away, unless the natural outfall be kept clear, or unless an appropriate artificial outfall be provided and kept open."

I would respectfully suggest to this Board that their influence could be usefully exerted in procuring such legislation as would make these improvements effectually, and without being burdensome.

III. ON THE SOILS OF THE STATE, &C.

A beginning has been made upon this subject. A large collection of soils from different parts of the State has already been selected. It is, however, only the beginning of what is needed. By continuing to collect, analyse, and describe soils, we shall finally get together material which will make a classification of our soils possible, and enable us to present principles which must influence the practice of tillage. The soils have a general resemblance in composition, to the rocks which underlie them, and as the rocks extend in belts, across the State from northeast to southwest, the various classes of soils must also lie in the same way. And if a whole belt of soil has the same general character and composition, it necessarily follows that all parts of it are adapted to the same management, and that the same principles of tillage and fertilization should be used throughout the whole. When general principles like these can be established and brought to the knowledge of the great body of farmers, then their united efforts will be intelligently directed, and the methods of a sound practice regulated and put in operation. There has heretofore been little profit derived from the analysis of soils, but it does not follow that it must be so in the future. There has been a lack of scientific knowledge, to rightly interpret the results of analysis, but this will be met when the attention of whole communities is drawn to the same points.

An application of these statements may be seen in the soils of the valleys in which *magnesian limestone* is the underlying rock. Soils and subsoils to the number of twenty specimens have been selected from various parts of these valleys in Sussex and Warren, and in Pennsylvania from the New Jersey boundary southwest to Lebanon. The following table gives in the first column the average of ten soils, and in the second column the average of ten subsoils.

Analyses.

Silica,	67.88	65.31
Per-oxide of iron,	4.57	8.11
Alumina,	12.88	13.10
Oxide of Manganese,	.44	.37
Lime,	.96	.59
Magnesia,	1.47	1.34
Potash,	2.90	3.87
Soda,	.43	.69
Phosphoric Acid,	.78	.80
Sulphuric Acid,	.03	.04
Organic Matter,	6.61	3.72
Water,	1.61	1.70
	100.56	99.64

These soils have been noted for their fertility, and have been cultivated ever since the first settlement of the country. They are specially adapted to the growth of wheat, and have always yielded good crops even under the worst of management. The analysis shows that they contain an abundance of all the essential elements of fertile soils; the phosphoric acid, potash, lime, magnesia, and sulphuric acid. The practice of farmers is to enrich these soils by the addition of lime, and by raising clover.

It is not thought profitable to keep any stock upon it except sufficient teams to do the work. Plans to increase the supplies of barn-yard manure, like those pursued in less favored soils, are not thought necessary. Lime causes the mineral ingredients to become soluble, and clover supplies the elements of ammonia. With analyses like these, the intelligent farmer is prepared to lay out his plans for farm management. He knows that he need not buy manure; his attention must be directed to the best tillage and cropping to bring out what is already in the soil.

IV. IRON ORES.

The mining of magnetic iron ore is carried on to about the same extent as in former years, and there is a reasonable prospect that the rich mines now worked will continue to meet the large drafts made upon them for many years to come. The demand for ores is large, and the stimulus to renewed efforts after new mines is great. The veins which were discovered two or three years ago, near Chester, Morris county, are still being worked, and further explorations made, with encouraging results.

The annual supply of magnetic iron ore from the mines could be largely increased, if there were some cheap and easy mode of removing sulphur from the ores. There are many veins and parts of veins of ore which contain a small percentage of sulphur, and for this reason are considered worthless. The common method of roasting sulphurous ores drives off a very little sulphur, but not enough to make the very large quantity of ore now in rejected mines suitable for the forge or furnace. Mr. A. S. Hewitt's Exposition Report *On the Production of Iron and Steel* states that "In the preparation of ore for the blast furnace, Sweden exhibits the model of a roasting furnace invented by Mr. E. Westman, and which was adopted, in the first place, at Dannemora works, and since generally introduced at the other iron works in Sweden. It consists of a vertical furnace, which is heated by a portion of the gas drawn from the blast furnaces themselves, and introduced at the bottom of the roasting furnace through suitable flues, by the aid of natural draught. The temperature in the furnace is carried to such a degree as to soften the ore, and drive off the sulphuric acid arising from the oxidation of a portion of the sulphur, disengaged, by a distillation of a lower temperature, from the pyrites which may be mixed with the ore; a portion, moreover, of the sulphur is oxidized by the oxygen of the ore. Ore thus roasted, however dense when charged into the roasting furnace, is discharged at the bottom quite porous, like a sponge, and almost entirely free from sulphur, if it do not contain more than four per cent. in its natural state. With ore so roasted, and which presents an entirely different appearance from ore prepared in a common kiln, the statement is not surprising that the blast furnace runs with far greater regularity, and with much less consumption of fuel. The introduction of this roasting furnance will be of great value when magnetic ores are smelted with charcoal. It is highly probable that even in furnaces fed by mineral coal, it will bring into economic use a great variety of ore now rejected on account of its sulphur. So important did this furnace appear, that the writer at once engaged a Swedish engineer to proceed to America, and erect a furnace at Ringwood, in New Jersey. The furnace was built and tried, and its performance is more than equal to the promise. It can be examined by the public at any time.

"Besides economizing coal, the Westman furnace, in connection with other improvements resulting from a more accurate knowledge of the theory of the blast furnace, and a careful study of its operation, has greatly increased the weekly product of the charcoal furnaces in Sweden. The general dimensions of the blast furnaces are from eight to nine feet across the boshes, and from forty to fifty feet in height. The average product of these furnaces, driven with a blast heated to 150° or 200° centigrade, is about seventy-five tons per week, which is nearly double the product made a few years since, and now made in the United States from the same class of magnetic ores, which must by carefully distinguished from the brown hematites of Connecticut and the per-oxides of Lake Superior. The charging of the furnace, in particular, is most carefully attended to; absolute uniformity in the sizes of the pieces of ore is insisted upon, and the charge is distributed over the furnace by a shovel, in which it is first weighed, and then run on a suspended railway to the tunnel head of the furnace, which is never closed. The most intelligent engineers expressed the opinion that the furnaces would give better results if made larger; but as they are, 100 pounds of cast iron are produced with ninety pounds of charcoal, which is as near as possible at the rate of 112 bushels to the ton."

The introduction of improvements like these, in our iron works, would bring into use thousands of tons of ore that are now considered worthless. It would also increase the manufacture of charcoal iron, which is so necessary for the production of the best qualities of steel. The charcoal blast furnaces now in common use require 200 bushels of charcoal for each ton of iron made from magnetic ore.

Hematite ores have been much sought after in our State, for the purpose of mixing with the richer magnetic ores, mixed ores working much more freely in the blast furnace than the magnetic ores alone. A large amount of these ores is taken from various localities in the valleys where magnesian limestone is found, for the Pennsylvania blast furnaces. This limestone occurs in great abundance in New Jersey. All the limestone valleys southeast of the Blue mountain, in Sussex and Warren counties, are underlaid by this variety of rock. Heretofore very little hematite has been found in the State. The Edsall and Pochuck mines, near Hamburg, have been the most productive, and some small workings have been carried on at various places along the Musconetcong and Pohatcong creeks. In the summer of 1868 a deposit of hematite was found on the farm of Thomas Shields, near Beattystown, Warren county. Some of the ore was taken out, tried, and found to be of good quality. During the present season about eight hundred tons of the ore have been sent to market; trial pits have been sunk over an area of several acres, ore was found in all of them, and a steam engine and appliances for raising and washing the ore have been put up on the ground. The workings show a large body of good ore, and there is no question that this mine will yield an abundant supply for many years to come.

The success which has attended this enterprise has encouraged others in these valleys to search for similar ore, and there is a reasonable prospect of its being found, in many places. The search for this ore should be limited to the limestone valleys. It is not magnetic and the compass cannot be used in searching for it. Its surface indications are found in little fragments of the ore scattered on and through the soil, and in an occasional boulder of the ore. The *final proof* of ore being in any place, is, of course, by digging down through the earth until the ore, or solid rock is found. No blasting of rock is needed. Leslie, in his Iron Manufacturers' Guide; p. 570, says: "Among the circumstances which usually indicate an abundance of the limestone ore beneath the soil, it should be mentioned that one of the most essential is a considerable thickness in the deposit of ferruginous loam, clay, or other earthy matter, resting on the strata. This will, of course, be marked by a corresponding evenness of the surface; for when the beds of limestone are naked of soil in many places the covering of earth, which must contain the ore, can nowhere be deep. Another very necessary condition is, that the earth overlying the rocks should have a large amount of oxide of iron diffused in it. This will show itself by a characteristic bright yellow or clear brown color. It must be observed, however, that the existence of a large quantity of oxide of iron in the deeper part of the soil will very frequently not be perceptible in the color of the surface of the ground—the ore being confined to the lower portions of the mass—so that much good ore-ground is often neglected from want of preseverance in digging."

The search for ores of this kind must necessarily be the work of individual enterprise, but the laboratory of the survey is open for the testing and examination of samples for their benefit, and the members of the survey are ready to give any information they may be able, facilitate the search. Those wishing specimens examined are invited to send them to the office of the Geological Survey at New Brunswick; with as full an account as possible of them and their location.

V. FIRE AND POTTERS' CLAYS.

The rich deposits of Fire Clay at Woodbridge, South Amboy and Trenton, are gradually growing in reputation. They are purer and richer than the foreign clays, yet they have been sold at less than a quarter of the price which those bring. They stand fire better than any imported clays, yet fire clays and fire bricks are brought in and sold at prices far above those asked for our own. There are differences in the modes of working different clays, and it is probably owing to the want of skill in managing ours that has kept them from being estimated at their true value. Heretofore all the clay used in making the melting pots for glass-houses, was brought, either from Europe, or from the vicinity of St. Louis, in Missouri. Nearly two years ago, at the request of Wm. B. Dixon, of Woodbridge, we called the attention of several glass manufacturers to the excellent qualities of these clays, urging that they would answer for the glass-house pots and furnaces, when properly worked, and that a great saving could be effected by using them. A letter has lately been received from Whitall, Tatum & Co., of the Phœnix Glass Works at Millville, in which they say they have been using Mr. Dixon's Woodbridge clay, more or less, for about two years, "in furnace work and in pots for making glass. It appears to us, after this trial, fully equal to Missouri or German clay, and we think this discovery will lead to sales of $50,000 a year of this clay, instead of importations from Germany or England, or freighting from Missouri."

This result is a source of great satisfaction to me, for these fine clays have heretofore been wasted on objects which could just as well have been made from inferior clays, and the most accessible localities were being exhausted before the rare qualities of the material were at all understood. It is to be hoped that our manufacturers will soon bring the requisite skill and intelligence to bear in turning these clays to the best account.

Clay suitable for porcelain, fine and common pottery, paper facing, alum, fire brick, glass-pots, crucibles, stone ware, sewer pipes, &c., can be found in any quantity; and the poorer clay makes the strongest brick and drain pipe that come into market. The belt of country in which these materials is deposited, is admirably located for a great business, and the potteries, fire brick factories, &c., at Trenton, Woodbridge and Amboy show only a fraction of what this business will be in a few years.