CHAPTER IV.

FORMATION OF THE SOILS AND SUB-SOILS. THE QUATERNARY.

1. *Thickness of the Drift.*

At no place within the limits of Bay county does bed rock reach the surface. The depth of the drift formation varies from 30 feet in the northern part of Fraser township to 220 feet in the vicinity of Auburn, and 227 feet in the northwest quarter of section 21, Beaver. This great accumulation of drift is doubtless exceeded in depth farther west, inasmuch as a test hole for coal put down by J. Coryell in section 24, T. 15 N., R. 2 E., and just over the line in Midland county, shows 249 feet of unconsolidated material above the bed rock. Another drilled well near the north quarter post of section 18, T. 14 N., R. 3 E., has 217 feet of drift and no rock. In the northwestern part of Bay county, the elevation of the bed rock increases, but the greater development of the drift leaves the minimum amount of drift formation as noted above in Fraser township. Thus we have 115 feet of drift in a well recently put down by Wm. Hinman at Bently, at 737 feet A. T., which makes the bed rock at 622 feet or approximately 60 feet higher than the highest rock elevation in Fraser township.

Additional details showing the thickness of the drift in the northern part of the county are rather wanting. The records of three test holes for coal put down on the property of J. Mansfield in the southwest quarter of section 11, Mt. Forest township, show from 90 to 92 feet of drift. At Mt. Forest station bed rock is said to have been struck at 90 feet. In the southern part of the township, two test holes for coal in sections 33 and 34, show respectively 107 and 121 feet of drift. To the eastward in Pinconning township, the amount of drift varies from 35 to 40 feet as in the eastern part of the township, to 73 feet in section 19 adjacent to Mt. Forest. A comparison shows that the amount of drift increases westward from the bay shore, to the Gladwin county line. At Estey there is 137 feet of drift, or considerably more than has thus far been obtained in either Mt. Forest or Pinconning townships.

We have already had occasion to notice the subordinate bed rock divide, having a lobate structure, which opens out to the northward from Michie P. O., in the northern part of Fraser township. In this area there is only 28 feet of drift in the southeast quarter of section 2; in the N. W. ¼ of the S. E. ¼ of section 4, the drift amounts to 30 feet, increasing to 45 feet in the N. W. ¼ of the same section, and to 72 feet near the south quarter post of section 4. A drift filled channel apparently heads in near this last location, meandering southwest and across the southeastern portion of Garfield township. In this old drainage channel there are two wells which reach the rock at a depth of 90 feet in sections 16 and 19 of Fraser. Northwest and southeast from here the drift varies from 70 to 80 feet in depth, at slightly different elevations above the bay. In the N. E. ¼ of section 24, Garfield, we have from 80 to 100 feet of drift, the amount increasing to the southeast as we approach this buried channel, designated the Beaver washout in our chapter on coal. In these two records the upper half is clay, probably of Wisconsin age. In the southeast part of the same section we have 65 feet of clay and 45 feet of sand down to a depth of 110 feet. Across the township line from here, in the N. W. ¼ of section 30, Fraser, there is from 106 to 110 feet of drift, the upper 70 feet being of clay, the balance of sand, gravel and clay. The general tendency is for the drift to increase in depth toward the southwestern part of Fraser, north of that corner of the township. Similarly the depth of the drift in Garfield township increases to the south, and more especially in the southeastern portion adjacent to the area in Fraser township just described. Near the southwest corner of section 4, Garfield, Mr. F. J. Tromble went through 127 feet of drift, which is approximately the same as was found in the south central part of Mt. Forest, less than two miles north. This rapid increase in the elevation of the bed rock towards Mt. Forest Station northward, indicates that the depth of the drift increases toward the south in Garfield, forming a part of the gradual increase in morainal accumulations toward the southern and southwestern portion of the county.

In conformity to this we have in S. W. ¼ of section 32 of Garfield, T. 16 N., R. 3 E., 180 feet of drift, the upper 65 feet being clay, probably of Wisconsin age, the earlier beds of sand and clay being at least pre-Wisconsin in part. In the S. W. ¼ of section 33, one mile east, there is 148 feet of drift, the top eight feet being sand underlain by 47 feet of clay; the balance is sand. Near the south quarter post of section 26, Garfield, there is about 135 feet of drift.

The Beaver washout which extends south and west, through the central and southwestern part of Beaver township, has a great accumulation of drift material where the bed rock has been washed away. Following down the main area of this buried valley, as near as our data can locate the same, it is noticeable that the amount of drift constantly and rather rapidly increases southward. In the N. W. ¼ of section 2, Beaver, we have 135 feet of clay and 27 feet of sand; in the N. E. ¼ of section 3 there is 116 feet of clay and 69 feet of sand; both drill holes entered the rock. This is 115 feet more drift than where the channel heads in Fraser township. At Kimel's store, near the N. W. corner of section 21, Beaver, there is 227 feet of drift; in the northwest quarter of section 33, 225 feet. Northwest of this area the depth of the drift, as far as we can ascertain from certain records in Midland county, and from a drill hole for coal in the N. E. ¼ of section 7, Beaver, decreases to 119 feet in the latter place. East of the Beaver washout, and in the eastern part of the same township, there is near the west quarter post of section 23 eight feet of lacustrine sand deposits at the surface, underlain by 37 feet of clay and 123 feet of sand, rock being struck at 168 feet. This is 59 feet less than two miles to the westward. Comparing this record with the one in the N. W. ¼ of section 2, about three miles to the north, we have the amounts of clay and sand almost reversed. This may be due to the sand being pushed forward by the advance of the Wisconsin glacier. Anyway these two records show the great variability of the drift through this region. Near the west quarter post of section 24, at Loehne P. O. there is said to be 136 feet of drift or 32 feet less than about one mile to the westward. South from here in the east part of section 34, two well records show from 70 to 85 feet of drift or 32 feet less than about one mile to the westward. At Soper's mill near the southwest corner of section 2, it is said to be 150 feet to the rock.

In the continuation of this heavy drift filled channel into Midland county, there is 249 feet of drift in section 24, T. 15 N., R. 2 E.

Extending east from Beaver the accumulation of drift material in Kawkawlin township, is comparable to the section in the last northern tier of townships, in that the amount of drift material constantly decreases in depth toward the east, which is also true in a general way with Fraser and Garfield. The greater amount of drift deposited in Beaver township, is in line with the more massive deposits in the southwestern portion of this township, and consequently the section is more strongly accentuated toward the west than in the next tier of townships to the north.

An examination of rather numerous well records collected by W. T. Shaw throughout Kawkawlin township, and the records of 19 test holes for coal put down in the eastern portion of the township adjacent to the bay, indicates that the amount of drift varies from 80 to 90 feet in the western tier of sections, to from 58 to 74 feet in the area adjacent to the bay. As will be seen by referring to the rock contour map, there are apparently no washouts in the bed rock underlying Kawkawlin. The area adjacent to the bay, is underlain in part by massive beds of sandstone, which may account for the lesser amount of drift deposited. This is quite noticeable in the southern part of the state, where the Marshall sandstone has relatively a small amount of superincumbent drift materials, when compared to the adjacent Coldwater shales to the south and east.

In T. 13 N., R's. 4 and 5 E., and T. 14 N., R's. 3, 4 and 5 E., corresponding with the civil divisions of Frankenlust, Williams, Monitor, the Bay Cities, and portions of Bangor, Hampton and Portsmouth townships, the distribution of the drift formation is very irregular. I will first attempt to give the main features of this area, adding such details as may seem necessary to give a correct idea of the drift distribution in this area. In Williams, T. 14 N., R. 3 E., the Beaver washout in its higher portion includes the northwestern part of this township. Westward in Midland county, this washout unites with the Auburn washout, or old buried valley, which runs under that village, and probably south of the Midland stone road, heading in north of Colfax P. O., near the line of sections 21 and 28, T. 14 N., R. 4 E. This Auburn washout received from the north, a tributary valley which runs northeast in the northwestern part of Monitor. West of this tributary valley and extending down into section 17, Williams, the bed rock rises having a much less amount of drift accumulation. Also the drift is less in the southeastern part of Williams, extending into section 27, T. 14 N., R. 4 E., northeast of Colfax P. O.

The Amelith washout extends from near the mouth of the Saginaw river, west and south through the central part of Bangor township, the eastern part of Monitor township, and thence through the northern part of Frankenlust township, having a much greater amount of drift than in narrow adjacent areas in its lower reaches, the amount of drift increasing about half. In its upper reaches, however, the drift is more constant and evenly distributed beyond its limits. This Amelith washout is separated by a bed rock divide from the Souwestconning washout underlying the Middle ground, and running mainly southwest through the eastern part of Frankenlust township. West of the northern part of this last area, in section 19, T. 14 N., R. 5 E., there is a comparatively small amount of drift east of the Amelith washout in Monitor township. The remaining eastern portion of Bay county has a comparatively even amount of drift accumulation.

I will now proceed to give some idea of the thickness of the drift in these areas, taking them up in the same order.

The border of the Beaver washout in the northwestern part of Williams township is based altogether on comparative data. In the N. W. ¼ of section 33, Beaver, there is over 225 feet of drift. In the S. E. ¼ of section 17, Williams, we have 65 feet of clay and 22 feet of sandy clay above the bed rock, showing a decrease of over 138 feet in the amount of drift within four miles.

In the Auburn washout it is 220 feet to rock at the village of Auburn. In the S. ½ of the S. E. ¼ of section 13, Williams, we have 65 feet of clay and over 141 feet of sand, somewhat above the point of juncture of the tributary valley, mentioned as coming in from the northwestern part of Monitor township. East of Auburn this buried valley swings slightly to the south of the Midland stone road in the west half of Monitor township. In the southeast quarter of section 21 there is 148 feet of drift, the upper 74 feet being clay and hardpan, the balance sand and gravel. Within a few rods to the north, in the same quarter section, we have 90 feet of clay above the rock. Near the east line of the same quarter section there is 65 feet of clay and 34 feet of sand. I believe that this washout heads in near here. Thence east near the divide between this washout and the Amelith washout which runs south near the line of sections 23 and 24, we have on this divide in the S. W. ¼ of section 22 only 73 feet of clay drift increasing to 95 feet of clay and 5 feet of sand in the N. E. ¼ of section 22 and 115 feet of drift in the S. E. ¼ of the same quarter section.

We will now take up the area in the northern part of Monitor township lying north of the Auburn washout, west and north of the Amelith washout, and east and north of the tributary valley to the Auburn washout running through the northwest part of Monitor. In the south half of section 19 we have from 114 to 125 feet of drift, the upper drift series being from 67 to 90 feet thick. In the north half of the same section the drift decreases in depth to 70 and 77 feet, the amount of clay drift being 60 and 48 feet respectively. Thence north in the south half of section 18, and south of the tributary Auburn washout, the drift varies in depth in the south half of the S. W. ¼, from 107 to 140 feet, within 100 feet going northwest. About 80 rods west of here there is over 206 feet of drift, the upper 65 feet being clay, about the same as in the two holes to the east. In the S. E. ¼ of section 18, there is from 92 to 109 feet of drift, the upper clay formation varying from 70 to 85 feet. The tributary valley area north from here will come in for remarks in the next paragraph. In the tier of sections 20 and 17, lying east of the last two discussed, we will begin at the south and work north as before. In the south half of section 20 the drift increases in depth toward the north and south quarter line. We thus have near the south quarter post of section 20, over 143 feet of drift, the upper 94 feet being the upper clay formation. Going west, in the S. W. ¼ of this section, the drift decreases in depth from 138 feet to 113 feet near the west line of the section, with from 59 to 65 feet of clay drift on top. In the S. E. ¼ of the S. E. ¼ of Sec. 20, there is 149 feet of drift on the northern border of the Amelith washout, the lower 93 feet being sand. In the N. E. ¼ of the same quarter section we have only 94 feet of drift. In the north half of section 20, we again find the drift increasing in depth toward the south central part, or the center of the section, where it is 131 feet to rock, the upper 60 feet being clay. In the S. W. ¼ of the N. W. ¼ there is 100 feet of drift, the lower 50 feet being sand and gravel. In the N. E. ¼ the drift varies from 95 to 118 feet, the upper clay division being from 60 to 104 feet thick. In section 17 to the north, the drift increases in depth to the westward toward the Auburn tributary washout. We thus have in the N. W. $\frac{1}{4}$ over 150 feet of drift, the upper 100 feet being clay. Near the N. and S. $\frac{1}{4}$ line of the section the drift is from 114 to 149 feet thick, the upper 60 or 70 feet being clay and hardpan underlain by beds of sand and gravel. Near the east line of the section there is from 58 to 81 feet of drift and from 2 to 5 feet of sand and gravel above the rock. This section east and west, not only serves to give an idea of the thickness of the drift, but also of the relative thickness of the underlying beds of sand and gravel, as we approach the washout areas. In the next tier of sections, east of the last described, numbered 21 and 16 in the township survey, the drift generally increases in depth to the south and east; in other words toward the Auburn and Amelith washouts. Near the south line of the section there is 148 feet of drift, the upper 74 feet being clay; near the north line we have from 85 to 107 feet of drift, the upper beds being from 62 to 98 feet thick. In the west part of the section, the drift formation is from 95 to 110 feet thick in three holes; in one we have 100 feet of clay down to the rock, the other two have from 45 to 60 feet of sand and gravel beds below the clay. Obviously the drift formation here is very unequally formed, even outside of washout areas. Near the east line of the S. E. $\frac{1}{4}$ there is from 99 to 103 feet of drift. In section 16 we have from 88 to 121 feet of drift near the south line, decreasing to 77 feet near the north line of the same section. In section 22, we have in the S. W. $\frac{1}{4}$, the northward extension of the bed rock divide west of the Amelith washout, and demarking the head of the eastward extension of the Auburn washout. In this area there is from 73 to 79 feet of clay drift down to the rock. East from here, as we gradually descend into the Amelith washout, we have in two drill holes 100 and 115 feet of drift, the latter being all clay. North from here in section 15, there is 90 feet of drift at the west quarter post. Near the northwest corner of section 14 there is 104 feet of drift, the lower 60 feet being sand. The area east from here will come in for remarks in connection with the Amelith washout. In sections 10, 11 and 12, east of the Auburn tributary washout we have only five drill and two well records into the rock. Near the west quarter post of section 10, it is only 62 feet to rock, increasing to 89 feet east of the northwest corner. In the south half of section 11 we have from 109 to 120 feet of drift, the upper 90 feet being clay; in section 12 the drift increases from 58 to 116 feet going south toward the Amelith washout. In the north tier of sections forming Monitor township we have at the Kawkawlin dynamite works 80 feet of drift. Near where the Auburn tributary washout is supposed to start in section 5, there is 110 feet of drift, the upper 82 feet being clay. In the S. W. $\frac{1}{4}$ of section 6 we have 80 feet of clay and 8 feet of sand.

We next come to the Auburn tributary washout mentioned as running through the northwest part of Monitor, and section 13 of Williams, in a northeasterly direction. In the S. E. $\frac{1}{4}$ of section 13 we have over 206 feet of drift, the upper 65 feet being clay. To the north and east, we have less than 95 and 107 feet of drift respectively, within half a mile. In the northwest $\frac{1}{4}$ of section 17 it is over 150 feet to the rock, and near the south quarter post of section 7 we have 140 feet of drift, which decreases to 98 feet within half a mile northward. Mention has just been made of where this washout probably heads in section 5.

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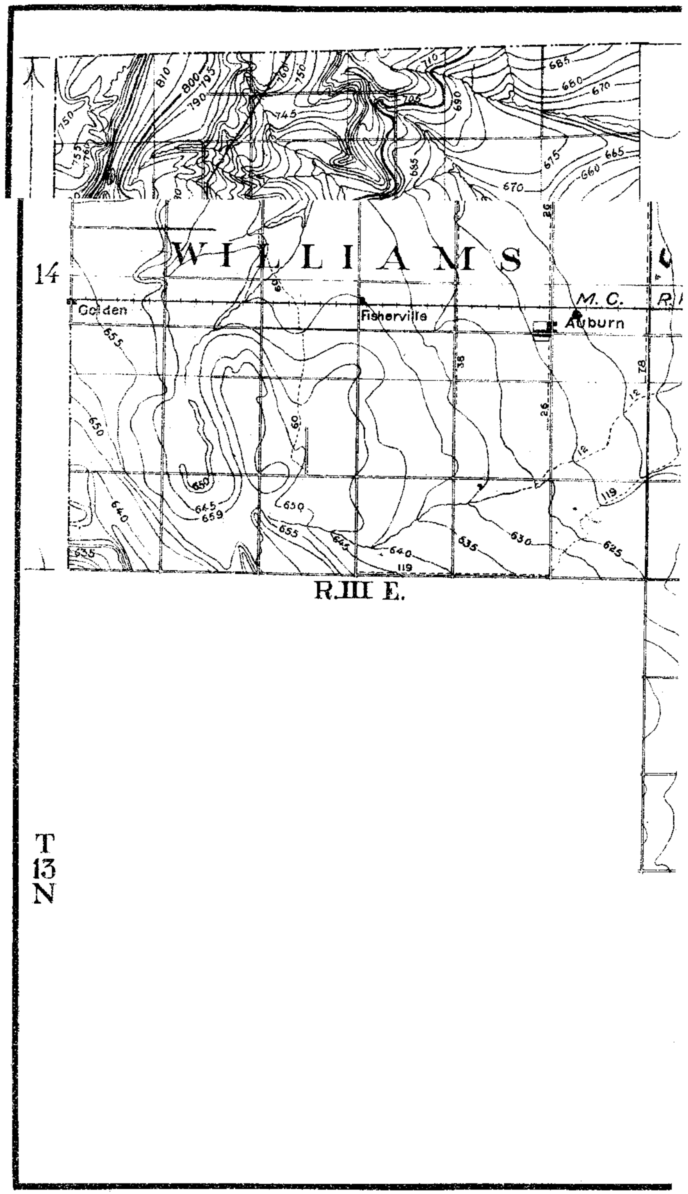


occupying the greater portion of the northern half of Williams township, we have some data to offer. In section 13, Williams, and on the north side of the Auburn washout there is 124 feet of drift, the upper 60 feet being clay. Going northeast along the rise of the bed rock, into the south half of section 7, Monitor, we have from 68 to 83 feet of drift, the greater part being clay. Adjacent to this, in the N. E. ¼ of section 12, Williams, we have from 70 to 92 feet of drift, the upper clay drift being from 60 to 92 feet deep. On the bed rock divide running northeast from near the southeast quarter of section 17, Williams, we have in this last place 87 feet of clay drift down to the rock. Thence northeast, in the S. E. ¼ of the S. E. ¼ of section 9, there is from 85 to 90 feet of drift. Near North Williams P. O., in the N. W. ¼ of section 11, Chas. Coryell went through 110 feet of drift. There is 93 feet of drift near the northeast corner of section 11, 124 feet one mile and a half south, and 220 feet at Auburn, which serves to give an idea of the profile across the north side of the washout. In the north tier of sections forming Williams township, we have in sections 2 and 3, from 75 to 90 feet of drift and apparently no rock. Near the southeast corner of section 4 at the Hardy place, there is 71 feet of clay and hardpan, 20 feet of fine sand, then 2.5 feet of gravel probably resting on the rock. In the northwestern part of Williams we only have one well into the rock. There is 198 feet of drift near the northwest corner of section 19.

We will now take up the region in the southeast part of Williams, the southwest part of Monitor, and that portion of Frankenlust north and west of the Amelith washout. This area is bounded on the east by the Amelith washout and by the Auburn washout on the north, in Monitor township. In the S. ½ of the S. E. ¼ of section 28, Williams, there is said to be 187 feet of drift. To the east, in sections 25 and 26, we have from 122 to 125 feet of drift and no rock. In the northeast quarter of section 34, Williams, we have a drilled well 143 feet deep, and 80 feet of clay on top. Thence east in section 30 of Monitor, we have on the farm of John Zill 57 feet of clay, 60 feet of sand, then gravel probably underlain by rock. In the S. E. ¼ of section 31, Monitor, there is over 130 feet of drift. South from here in Frankenlust I believe that the drift increases in depth. In the next tier of sections to the east, making sections 29 and 32 of Monitor, and 5 of Frankenlust, we have the records of a few drill holes for coal. In the S. E. ¼ of section 29 there is 121 feet of drift, the upper 105 feet being clay. Near the S. E. ¼ of the same section, going south from the Auburn washout, we have 115 feet of drift. Near the north line of section 5, Frankenlust, there is from 115 to 124 feet of drift, increasing to 127 feet in the center of the N. E. ¼ of the same section. Thence east again in sections 28 and 33 of Monitor, and 4 of Frankenlust, located west of the Amelith washout, we have the least accumulation of drift material in this part of Monitor and Frankenlust townships. This is just south of the area previously described in sections 16 and 21 of Monitor. In the south half of section 28 the drift decreases in depth near the southeast corner to 81 feet with only 74 feet in the adjacent quarter section to the east. West from here we have about 100 feet of drift. South from here in section 33, we have from 84 to 116 feet of drift, the greatest amount being toward the southwest. In section 4 of Frankenlust we have 90 feet of drift in the center of the section, and 111 feet near the shaft hole of Bay No. 2 mine in the S. E. ¼. Near the southwest corner of section 3, in the Amelith washout, there is over 190 feet of drift, which brings us to this subject.

The existence of this Amelith washout is somewhat insufficiently based on rather meager data, largely of a comparative nature. To the north and west of the test hole in section 3, S. W. ¼, the west and north sides of this channel respectively show from 131 to 147 feet of drift, which as we have seen, decreases to 104 feet in the center of section 4, Frankenlust. The records adjacent to the shaft of the Hecla Portland Cement & Coal Co., in section 2 of Frankenlust, also show a considerable falling off in this direction, there being from 68 feet of drift in the eastern part of the section to 123 feet in the northwest quarter. The same may also be said to be true in the territory contiguous to the Amelith shaft in section 15. Near the northwest corner of that section there is 168 feet of drift, which decreases to 132 feet within 40 rods to the southeast. Throughout the rest of this section there is from 106 to 147 feet of drift material. In the southwest quarter of section 17, Frankenlust, a well record gives a total depth of 137 feet to the rock. North from here in the north half of section 5 there is from 115 to 124 feet of drift. I have imagined these last two locations as being on the north and south sides of the Amelith washout. In the N. E. ¼ of section 35, Monitor, we have 175 feet of drift in the northerly continuation of this buried channel. In the N. W. ¼ of the N. W. ¼ of section 26, adjoining on the north, there is only 80 feet of drift on the west side of the washout. Going east and west across this washout, on the quarter line of sections 23 and 24, we have in the N. E. ¼ of the S. W. ¼ of section 23, rock at 107 feet; in the N. W. ¼ of the S. W. ¼ of section 24, from 88 to 130 feet of drift and 85 feet in the N. W. ¼ of the S. E. ¼ of 24. In section 12 of Monitor the drift increases from 58 to 106 feet in thickness going southeast toward this washout area. In the N. E. ¼ of the S. E. ¼ of section 7, Bangor, we have 175 feet of drift north of the bottom of this washout. In the north half of section 4, the drift increases from a depth of 72 feet, as near the shaft of Wolverine mine No. 1 and the Wenona beach mine, to a depth of over 178 feet in the washout south of the former location, and in the same section. About 80 rods south of here we have 90 feet of drift near the S. W. ¼ post of the same section. This washout probably heads over in Huron county passing near Unionville. The course is very narrow in places, with an abrupt descent which possibly accounts for the limited amount of information that I have been able to get concerning it.

On the bed rock divide east of the Amelith, and west of the Souwestconing washouts, we have in section 15 of Frankenlust, from 106 to 147 feet of drift with a well marked interglacial bed at 110 feet. The upper drift here has an average thickness of 114 feet being as usual underlain by beds of sand and gravel. Thence northeast along the bed rock divide, and in section 11, there is from 96 to 108 feet of drift in two drill holes there. In the adjoining section 12 to the east, we have in the north half, very nearly 80 feet of drift, increasing to over 162 feet where we get down into the Souwestconing washout at the south quarter post of this section. Thence north again in the east half of section 1, and the N. W. ¼ of the S. W. ¼ of section 6, just east, we get quite generally from 79 to 83 feet of drift in rather numerous records. In the property leased by the Hecla company in section 2 of Frankenlust, we have 24 drill records which show from 68 feet of drift near the south and east quarter posts of the section, to 120 and 123 feet near the west 80-rod line. The upper clay drift is from 64 to 120 feet thick. Thence northeast again along this old bed rock divide into section 36 of Monitor, we have the drift increasing in depth from 68 to 109 feet toward the north. In section 25 adjoining on the north, there is from 75 to 115 feet of drift from east to west as we get into the Amelith washout, but altogether rather irregularly distributed. East from here in sections 30 and 29 we get from 76 to 97 feet of drift. In West Bay City and section 19 adjoining on the west, the bed rock increases in elevation northward, having the least amount of drift formation in the north half of section 19 and the northwest portion of 20. In this area we have from 80 to 93 feet of drift on this old divide, increasing to 100 feet within a short distance. The drift in West Bay City is generally from 80 to 90 feet thick. South of the Amelith washout and the Kawkawlin river, and north of West Bay City, we have in 10 drill holes, from 78 to 90 feet of drift in Bangor township.

Data concerning the Souwestconing washout is rather wanting. In the southeast quarter of section 14, on the Neumeyer places, the drift increases from 82 to 130 feet in depth. Near the south quarter post of section 12 we have over 162 feet of drift, in the N. W. ¼ of 13, 109 feet, near the center of section 12, 80 feet. As we have seen there is 80 feet of drift around the Valley mine in section 1, T. 13 N., R. 4 E. From here the drift is 105 feet thick at the North American Chemical Company's deep well at South Bay City.

East of the Saginaw river and in that part of Portsmouth township included in the eastern half of T. 13 N., R. 5 E., there is from 80 to 125 feet of drift, rather irregularly distributed, but showing a tendency to increase toward the south. I did not obtain any records in the lowlands adjacent to the Saginaw river, with the exception of the record in section 5, at the deep well of the North American Chemical Co. at South Bay City. In T. 14 N., R. 5 E., either in or adjacent to the east boundary line of Bay City, we have 10 records from Goff Paul, which show from 88 to 105 feet of drift increasing in depth south and west, the same as in the adjacent township to the south where we have at least 125 feet of drift accumulation. This decrease continues to the northward, until, just east of the mouth of the Saginaw river, we have from 75 to 82 feet of drift on the Penniman property. In T's. 13 and 14 N., R. 6 E., included for the most part in the civil divisions of Merritt and Hampton townships, there is from 79 to 80 feet of drift, to as much as 108 feet in the west central part of Merritt. The greater part of our records indicate from 80 to 90 feet of drift.

An average of 460 drill holes for coal would make the thickness of the drift just 100 feet. These drill holes are all located in the lower third of the county, with the exception of 40 holes. Very nearly 365 records are in three government townships. A more even distribution of these records would doubtless give a truer idea of the average thickness. Additional information based on 126 well records scattered promiscuously over the county, make the average depth of the drift 86 feet. A combined average of our drill and well records would make the drift 97 feet thick in this county. In this estimate I have included the overlying lake sands deposited during the stages of the glacial retreat. For the average thickness of the different subdivisions of the drift, the reader is referred to the following section.

2. *Subdivisions of the Drift.*

In several drill and shaft holes for coal put down in the southern part of the county, beds of vegetation were passed through, which have been taken as either demarking the deposits of the Wisconsin epoch of glaciation from the pre-Wisconsin, or as forming subordinate divisions of the Wisconsin drift sheet. There are at least two beds of plant deposits contained in the Bay county drift, the upper bed probably subdividing the Wisconsin drift into two portions; the lower bed separating the Wisconsin from the pre-Wisconsin drift. The upper drift, mentioned in the preceding section is probably of Wisconsin age, and is composed of clay and hardpan, underlain by beds of sand, gravel and hardpan forming the lower or pre-Wisconsin drift.

Beds of vegetation were obtained by Leonard Zill in the center of section 19, Bangor township, at a depth of 80 feet; for 37 feet below the formation is said to be a boulder clay. As will be seen farther on, the depth of the deposit conforms in a general way with the main physical division of the drift formation in other sections. In the S. E. ¼ of section 28, T. 14 N., R. 4 E., near the old Monitor shalt, Goff Paul went through a bed of sand containing gas which has probably resulted from the decay of plant remains, at a depth of 80 feet. This was overlain by beds of clay and hardpan, and underlain by rapidly alternating deposits of sand, gravel and hardpan. The plant deposits here conform to the physical division into two principal parts, into which the drift deposits of Bay county have been divided. At the Hecla shaft in section 2 of Frankenlust, plant remains were found in beds of sand at a depth of 83 feet. This was here overlain by beds of clay containing boulders toward the bottom, and underlain by bed rock. There is just a possibility that this represents a preglacial soil deposit, but on the other hand this section is quite comparable to those already mentioned as being found at about this depth. I am inclined to believe that this deposit is interglacial, but with the underlying beds of drift not represented. The greatest development of the lower drift formation is found in the washouts where the earlier deposits were protected during the subsequent readvance of the ice.

The first specimens of interglacial wood were presented the Survey by Mr. John Werner, Superintendent of the Pittsburg Coal Company's shaft, situated near the center of section 15, T. 13 N., R. 4 E., and southeast of Amelith P. O. They were found at a depth of 110 feet. Not having a section of the shaft record I am unable to correlate these specimens exactly with any variation in the structure of the drift, but the average thickness of the upper or Wisconsin (?) deposits in the same section is 114 feet. The specimens present the aspect of being badly crushed by ice pressure. Prof. T. C. Chamberlin is of the opinion that these beds of clay and hardpan forming our upper drift, and underlaid with the bed of plant material from the above described localities, is of Wisconsin age.

The Wisconsin drift varies in our different drill records from 30 feet in thickness as in section 30, T. 15 N., R. 5 E., to 148 feet in section 15, T. 13 N., R. 4 E. An average of our maxima and our minima from 12 different government townships varies from 103 to 50 feet in depth. In 443 drill holes for coal the average thickness for the Wisconsin drift is 82 feet. It will be observed that this conforms quite closely with the depth of the bed of organic materials just described, with the exception of the Amelith plant deposit. This also indicates that the physical characters which I have used in working up the data agrees with the facts obtained from this plant bed. This bed will be designated the Lower Monitor soil horizon from its occurrence in the abandoned shaft hole of the old Monitor mine situated in the southeast ¼ of section 28 of Monitor, T. 14 N., R. 4 E. The very irregular distribution of the Wisconsin drift is well brought out in two drill holes in sections 2 and 23 of Beaver, in which we have 135 and 37 feet of Wisconsin drift underlaid with 27 and 123 feet of pre-Wisconsin beds, respectively. In the shaft of the What Cheer Mining Co., section 30, T. 13 N., R. 6 E., glaciated erratics were found in the Wisconsin drift at a depth of from 82 to 89 feet. These are also found at the surface in the same section and in other parts of the county. Also in the same shaft hole, there was a bed of soft blue clay 52 feet thick, down to a depth of 82 feet, overlain by hard clay. This may represent a bed of glacial or interglacial lake clay of Wisconsin age. It is not impossible that beds of clay may be deposited by fluvio-glacial action in the same manner as sand and gravel beds. We apparently have such a relationship between Lansing and the Agricultural College east of the city.

In the beds of clay and hardpan of Wisconsin age, just described, Goff Paul went through at the old Monitor shaft, a bed of plant remains four and a half feet in thickness at a depth of 45 feet. This was over and underlaid with deposits of clay down to a depth of 81 feet, where there was a bed of sand 10 inches in thickness. This sandy bed is at the same depth as the gas sand previously mentioned as occurring in the same quarter section, which demarked the lower limits of the Wisconsin drift. This has been designated the Lower Monitor soil. The much better defined soil bed mentioned above as being found at a depth of 45 feet, I will call the Upper Monitor soil. This latter soil bed is said to have preserved the impressions of the leaves in its strata, a fact which does not indicate very strong ice action. I have also seen a few twigs from the same deposit. Apparently the same horizon as was found in the Monitor shaft, was also struck in the N. W. ¼ of the S. W. ¼ of section 28 where a bed of sand containing gas was penetrated at a depth of 40 feet. This gas burned all night. The gas sand here was both overlain by and underlaid with beds of clay of Wisconsin age. The surface deposits just east of the Monitor shaft, and on the other side of the road, contain numerous specimens of recent shells, of which a list has been furnished the Survey by Bryant Walker. It is questionable to just what extent these surface beds and the deposits above the 45-foot Upper Monitor soil are of glacial or lacustrine age. This bed may represent a local subdivision of Wisconsin age. On the other hand, the drift deposits above the Upper Monitor soil bed may represent only the Wisconsin, the drift below this horizon, and above the Lower Monitor soil bed, being Illinoian drift. However, as just stated, Prof. Chamberlin is of the opinion that the drift formation above the Lower Monitor soil is of Wisconsin age, and will be so accepted.

PRE-WISCONSIN DRIFT. The records of 240 drill holes show beds of sand, gravel and hardpan below the upper Wisconsin beds of clay and hardpan, rather irregularly distributed, but having the greatest development where it was protected in washouts. The average thickness of these beds are 33 feet. In many localities the pre-Wisconsin drift is absent. The maximum thickness, so far as ascertained, is in section 23, T. 14 N., R. 3 E., depth 155 feet. An average of the maxima and minima of the different townships, is 62 and 122 feet respectively. These beds may have either been outwash from a pre-Wisconsin glacier ground moraine or formed in a pre-Wisconsin lacustrine area. At the Auburn shaft these beds are of sand, coal and bituminous shale, the latter having well rounded margins, as though due to fluvio-glacial action. Beds of sand make up by far the greater part of the pre-Wisconsin drift here. The amount of coal and bituminous matter both here, and in similar deposits at Auburn and South Bay City, rather point to the coal formation as furnishing material for at least a considerable portion of these beds. The sand may have its origin in part from beds of Coal Measure sandstone, and from the erosion of the Woodville sandstone which Winchell supposed formed the cap of the coal formation.

What are apparently deposits of post-Wisconsin age, are contained in the records of two drill holes put down by Goff Paul of West Bay City. In the center of section 10, Bangor township, he went through beds of sand and muck for a depth of 30 feet, which contained a deposit of logs and shells at the bottom. This was underlain by 80 feet of clay. Another similar deposit was found at the Corbin school in West Bay City, at a depth of 30 feet, and underlain by 50 feet of clay. Unfortunately we have not been able to obtain any of the specimens of shells in either locality. In the S. E. ¼ of section 24 of Kawkawlin township, the maximum amount of sand deposited over the clay amounts to 25 feet. I have taken these beds as late glacial deposits formed during the lacustrine period of the later Quaternary. Additional information concerning the thickness of the superficial sand beds will be found in the section dealing with the distribution and structure of the surface deposits, toward the end of this chapter.

3. *Moraines; the Lake History.*

In the discussion in the preceding portion of this chapter no mention was made of the agent by means of which the drift was accumulated. During a period geologically recent a great glacier descended from eastern Canada carrying with it a great burden of material, which was in part deposited as a ground moraine along and underneath the advancing ice; in part as moraines of recession in front of the retreating ice mass. Interglacial deposits indicating at least four stages of advance and retreat have been found in the region south and west of Michigan. In this state, however, the ice action being relatively more pronounced, and nearer the center of ice origin, the earliest stages have probably been obliterated, at least in part. During the retreat of the ice mass in Michigan, the ice formed a tri-lobate structure which has been designated, beginning at the east: The Huron-Erie glacial lobe, the Saginaw lobe, and the Lake Michigan lobe. As the ice withdrew to the northward this lobate structure became more pronounced, and the interlobate moraines, as well as moraines of recession were formed, the former in the sharply reentrant angles between the moraines.

Contemporaneous with the retreat of the ice, waterlaid moraines were deposited in areas ponded by the ice mass. Such a well marked moraine trends northwest and roughly parallel with the course of the Tittabawassee river, through the southwestern portion of Williams township. In the west part of Gibson township, what may be the continuation of this moraine, designated the Saginaw and Pt. Huron moraine, swings N. 26° E. This topographic feature is relatively much more abrupt on the side away from the ice, facing the west at an angle, in Bay county. This moraine is in general parallel with the present shore line of Saginaw bay. A similar morainal structure, but one of much lesser extent, causes the south fork of the Kawkawlin river to swing to the south in Monitor township, quite analogous to the greater loop of the Tittabawassee river, formed by the more pronounced Saginaw moraine. Both these moraines increase in elevation to the northward.

As the ice sheet melted back from the rim of higher land to the south. there was ponded between this divide and the ice margin, a series of lakes, Thus we have south of the Huron-Erie lobe, Lake Maumee which primarily discharged through what is known as the Fort Wayne outlet. After a time sufficiently long for a well defined beach to be formed on the shore of Lake Maumee, the ice of the Huron-Erie lobe melted back far enough for the waters of the lake to extend to Imlay, Michigan, where there was another place on the divide as low as the Fort Wayne outlet. A double line of discharge then followed, and the level of Lake Maumee was lowered a few feet. It remained at this level long enough to form a second beach. Likewise the melting back of the Saginaw ice lobe resulted in a lake in the plains adjacent to Saginaw bay and known as Lake Saginaw. This discharged past Pewamo into the Grand river, and is known as the Pewamo channel, or Grand river outlet. Lake Saginaw came into existence at a period subsequent to the outlet of Lake Maumee at Fort Wayne.

During the succeeding retreat of the Huron-Erie lobe the level of Lake Maumee was lowered about 30 feet, when the lake then discharged in the vicinity of Ubly, Michigan, into Lake Saginaw, receiving the discharge near Cass City. Because of the change in the geography this has been designated Lake Whittlesey.

The subsequent retreat of the ice on the "Thumb" of Michigan resulted in the coalescence of Lakes Whittlesey and Saginaw, resulting in the formation of Lake Warren which continued to discharge through the Pewamo channel, until the ice had melted back far enough to permit an outlet of the waters eastward to the Mohawk river. Lake Warren then ceased to exist but was succeeded by Lake Algonquin which occupied much of the area now represented by Lakes Superior, Michigan and Huron. This sketch may be somewhat modified by recent investigation.

During this period numerous beaches were deposited in Bay county between the land divides and the retreating ice dam. Beaches were formed at very nearly every stage of lake decline. Meander lines were run over nearly all these sand ridges, which are indicated as solid lines on the soil map. The general discontinuous formation of the sand ridges is probably due both to there being deposited on a lee shore, and to the comparative evenness of the drift.

4. *Early Beach Formations.*[1]

On the crest of the Saginaw moraine above described a well marked beach is developed at an elevation of from 825 to 830 feet at the crest, and on the top of the moraine. This beach is located in sections 7 and 18 of Gibson township and is rather interrupted in its course. This was probably formed in Lake Saginaw just outside the ice. During this period, and subsequent to the fall of the lake to about 750 feet A. T., this moraine jutted out to the south and west, forming a peninsula for some distance south and east of Estey. This may be the Belmore beach of southeastern Michigan.

On the flanks of this moraine, a beach is occasionally developed on the east and west sides of the moraine in sections 18, 19 and 30 of Gibson, where there is a rather rapid falling off of the crest of the moraine to the south. This beach is from 792 feet A. T. at the bottom, to 802 and 810 feet high at the crest.

On the west side of the Saginaw moraine the next highest line of beaches was formed at from 768 to 783 feet A. T. It is well developed in section 6 and the north half of section 7 of Gibson. This beach is occasionally interrupted by stream courses which either follow channels which have worked back and cut through the beach, or follow consequental drainage courses, the latter phase being indicated by beach lines which follow up the run banks for short distances.

[1] The elevations given are for the bottom and top.

Following the formation of the 768 foot beach, the lake extended northward as an inlet on the west side of the Saginaw moraine. In the east half of section 1, Bently township, Gladwin county, T. 18 N., R. 2 E., this beach formation faces the inlet on the west. The elevation of this beach here is from 748 to 763 feet A. T. East of this beach line and west of the moraine there is a rather narrow swamp impounded, and which extends along the entire west line of section 6 of Gibson and thence southwest into Gladwin county. This swamp is said to be interrupted by shallow bars or ridges extending across it. Crossing the Saginaw moraine to the east side, we again take up this 748 foot beach at substantially the same elevation as on the west side of the moraine. In sections 18, 19 and 31 of Gibson this beach is from 746 to 764 feet A. T. The beach here is rather more local in development, the greatest extent being in the west half of section 31. In places the ridge is interrupted by consequental intermittent drainage channels; again it merges into areas of thick white sand. I have correlated this old beach with the Upper Forest of Huron county. It may, however, prove to be the Arkona beach of southeastern Michigan. The elevation of the sand ridge in Huron county is from 744 to 774 feet A. T.

In sections 16 and 21 of Gibson, there is a sand and gravel ridge, having in places an elevation of 732 to 747 feet A. T. This would very likely make fair road metal if properly screened, and may be of value to the Bay County Stone Road Commission in their improvements in the northern part of the county.

Below this 732 foot beach there is an abandoned shore line which curves around in section 6 of Mt. Forest, and sections 20, 9 and 3 of Gibson township. The elevation varies from 716 to 721 feet at the bottom, to 727 and 733 feet at the top. In the north half of section 3 of Gibson, the beach forms a crescent opening out to the west, and is recessed by an intermittent run valley which was formerly an inlet of the lake. This beach is also finely developed on the east line of section 35, Adams township, Arenac county. I have provisionally correlated this beach with the Lower Forest in Huron county, with which it agrees fairly well in elevation. This may, however, prove to be the Upper Forest beach as originally defined. In sections 31 of Gibson and the adjoining section 6 of Mt. Forest, we have some hooked beaches probably forming delta formations, which were the debouchures of small streams which existed at about the time this Lower Forest (?) beach was being formed.

In sections 7 and 8 of Mt. Forest township there is a fine well marked beach which differs rather markedly from those heretofore described. In the south half of section 7 the top of this beach swings in at the top, the superimposed beach forming a reentrant angle toward the northwest, while the main basal beach continues on to the east-northeast. In the S. E. ¼ of section 7 this upper sand ridge gradually feathers out going northward. This feature is duplicated in the west half of section 7, except that the shore line is continued throughout the west half of the section, gradually becoming lower as we approach the county line, almost disappearing in Gladwin county. This second upper superimposed beach forms a broad V, opening out to the east, the lowest part being as described in the west half of section 7, the upper part again increasing in height where it swings northeast in the N. W. ¼ of the same section, thence swinging N. N. W. in the southwest quarter of section 6, until it finally disappears. In the N. W. ¼ of 7 there is a small reentrant beach running northwest, meeting the main beach at about right angles. The elevation of the bottom of the main beach in the south half of section 7 is 710 feet A. T. At the first reentrant beach in the S. E. ¼ of section 7, the top of the basal beach is 720 and the superimposed beach 734 feet A. T. The same elevations hold in the west half of section 7, and the southwest ¼ of section 6. Mr. Lane and I are of the opinion that the upper beaches may have been formed during storm periods when Lake Warren was temporarily reelevated. It is perhaps more possible that they may represent beach deposition, during a more prolonged reelevation of Lake Warren, or they may represent fragments of beach formations produced in the ordinary course of lake subsidence. The method of coalescence, however, is rather opposed to this view. This main beach probably belongs to the upper Grassmere, well developed in Huron county. Final investigation, however, may show that it is the Lower Forest.

In sections 9 and 16 of Mt. Forest township the next well developed beach line is found at an elevation of from 675 to 690 feet A. T., the average height being about 12 feet. North and south of Mt. Forest Station the course of this beach is mainly northwest and southwest respectively, being bounded on the north by the valley of Saganing creek, on the south by White Feather creek. During the time this beach was in process of formation I believe that these present consequental drainage valleys were occupied by inlets of Lake Warren, the beach being formed on a peninsula which now forms a divide between the two streams. South of White Feather creek, and in the S. E. ¼ of the S. E. ¼ of section 17, this beach forms a fine oval formation on the south side of the run.

Westward from there in the south half of sections 18 and 19, and through the central portion of 19, there are a series of beaches which form more or less a series of continuations of the 675 foot beach above described. These beaches, however, either swing into the north and drop off eastward, or gradually feather out. We very likely have a combination of beach and delta action. The elevation of the top of these ridges is from 700 to 720 feet A. T., increasing in elevation westward.

Again taking up our 675 foot beach as developed north and south of Mt. Forest Station, we find it locally developed between two of the forks of the Saganing, northwest of Mt. Forest Station. Just east of the northwest corner of section 11, Gibson, there is a sandy elevation having an altitude of 688 feet on its crest. This beach has been correlated with the Grassmere beaches in Huron county.

On the divide between White Feather creek to the north, and Pinconning creek to the south, there is another sand ridge which terminates in the S. E. ¼ of section 16, running thence continuously southwest through section 21, the south half of section 20, and terminating near the south quarter post of section 19. The elevation of the beach on the north line of section 21, is from 673 to 680 feet A. T. This beach faces the east and south, and was contemporaneous with the extension of Lake Warren up the basin of Pinconning creek. I believe that it was developed in the same manner as the beach formation just described as occurring between White Feather creek and the valley of the Saganing. South of Pinconning creek, this ridge is well developed in section 6 of Garfield where we also have some delta hooks or spits opening out to the west, thence extending northward through section 31 of Mt. Forest township, the north half of section 32, and the S. E. ¼ of section 29, where it swings around to the northwest south of Pinconning creek. In the north half of section 31 of Mt. Forest we have some local delta formations analagous to those in section 6 of Garfield.

In the western half of Garfield township, there is another lot of beaches which may form a continuation of the above shore line, the difference in elevation being either due to a slight falling off of the lake level, or to a slight increase in elevation northward. In the south half of section 5, Garfield, and thence east and north through the greater part of section 4, there is a well developed beach having an elevation of 667 to 674 feet A. T. This beach is also developed in the south half of section 8 and in the S. E. ¼ of section 31, Garfield, at very nearly the same elevation.

Near the head waters of Chute creek in section 4, which has been utilized as a drain east of Garfield township, and could be advantageously extended this far westward, the above shore line is comparable to the other beaches formed south of Mt. Forest Station, in that it has a general easterly trend, swinging off toward the north before running out. The shore of Lake Warren during that time must have presented a considerably indented line during its decline, with bays or inlets of the lake extending to the westward.

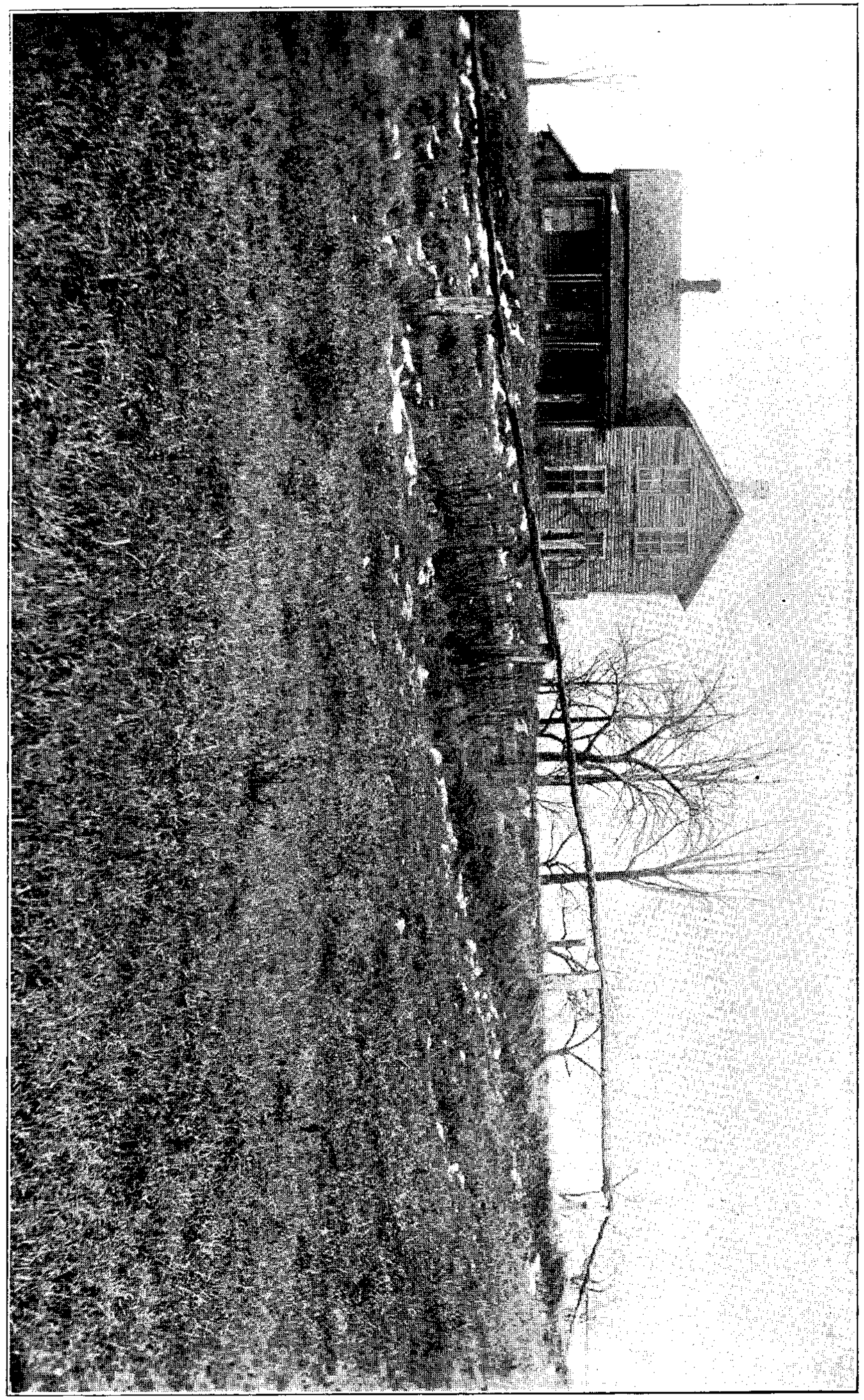
At the close of these beach formations there was a drop of about 10 feet in level of the lake, when another rather prolonged halt took place, during which time rather numerous interrupted shore lines were formed, extending from near the southeast corner of section 32, Williams, into Garfield township. The bottom of these beaches is from 650 to 660 feet A. T., the top from 660 to 672 feet. In Williams township this beach has only been observed on the Saginaw moraine in section 32, in Beaver township at the northwest corner of section 19, and on the north line of section 18 near the northwest corner where the elevation is 662 feet at the top. In Garfield township this beach is occasionally developed on both the east and west sides of the north fork of the Kawkawlin river, being found near the southwest corner of section 31, the northwest corner of section 30, and just west of the center of section 18. East of the river, Mr. John H. Blomshield obtained the elevation of this shore line quite accurately from a line of levels extending west almost across the township. He makes the elevation on the north line of section 16 from 660 to 669 feet A. T. It is also found at very nearly the same elevation in the east half of section 7, and the west half of section 17, Garfield, running south-southeast on top of the east valley wall of the North Fork. From the southwest quarter of section 17 the beach veers around to the west, until it abuts against the east bank of the river, in the southeast quarter of section 18. The elevation is the same here as on the north line of section 16. Subsequently the lake continued to extend up this valley, forming a well marked beach on its east divide continuously at lower elevations as far south as the northwest quarter of section 29, where the beach has an elevation of about 638 to 649 feet A. T.

In the interim between the formation of the beaches having an elevation of from 638 to 660 feet A. T. at the bottom, in the western part of Garfield, there is an occasionally well developed shore line in Williams, Beaver and Garfield townships at a height of from 644 to 654 feet A. T. In the western tier of sections forming Williams township, this beach is quite persistently developed at an elevation of from 642 to 650 feet A. T. The elevation of this beach conforms to that of the Elkton beach in Huron county formed during the later stages of Lake Warren. There is also another beach formation intimately connected with the preceding, occasionally developed in the western part of Williams, Beaver and Garfield, at a height varying from 631 to 649 feet A. T. While the top of these beaches is quite generally at an elevation of from 647 to 649 feet A. T., the elevation of the foot of the ridges varies from 631 to 642 feet above sea level. It may be that here we have off-shore bars represented in part. These beaches have substantially the same elevation on the east and west sides of the moraine in the southwestern part of Williams township, and are, I presume, to be correlated in a general way with the Elkton beach developed in Huron county.

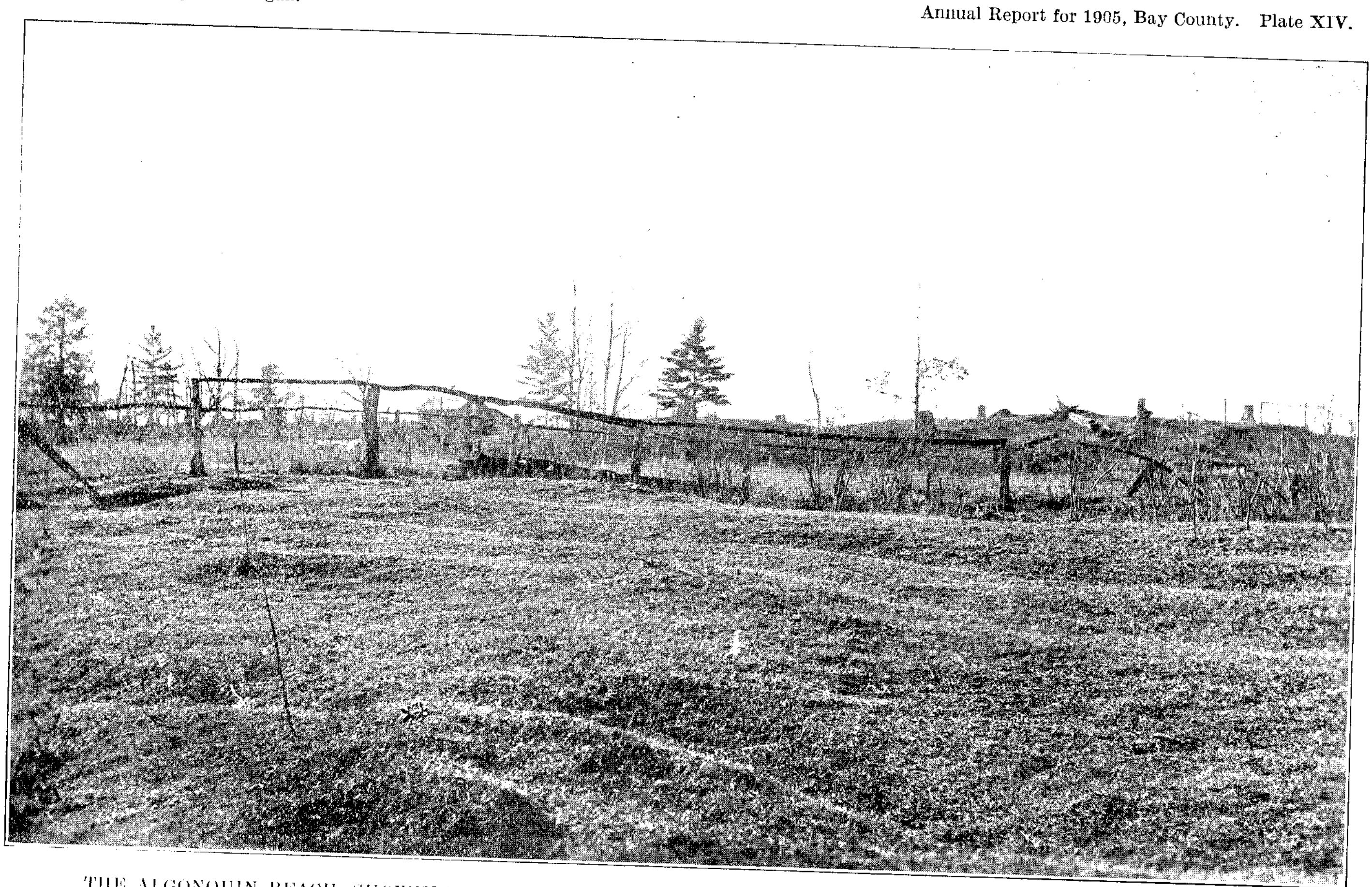
Next to the Algonquin beach, the most persistent shore line in Bay county is found at an elevation of about 633 to 625 feet A. T., at the top and bottom. On the west side of the moraine, in the southwestern part of Williams, the crest of this beach is 633 feet A. T., a short distance east of Smith's Crossing. On the east side of the same moraine, the same shore line is found slightly developed on the line between Frankenlust and Tittabawassee townships. On the east and west quarter line of section 1, Williams, there is a very pronounced ridge locally, with an elevation of from 618 to 633 feet A. T. Southeastward from here, as we shall see farther on, this beach forms a number of terraces, but is otherwise quite continuous, dropping off into the level of the Algonquin shore line. Northward, however, this beach is quite persistent in elevation. There are rather numerous sand ridges developed adjacent to the town line between Beaver and Kawkawlin. The elevation here is from 618 to 634 feet A. T. The beach lines here are occasionally very irregular, this probably being due to the open shore line to the east and west. This area is a low water laid moraine, bounded by the valleys of the North and South Forks of the Kawkawlin river, forming former inlets of the lake which gave free play to wave action, from the east and west. In sections 27, 28 and 34 of Garfield, this beach is sometimes well developed, the crest being about 642 feet A. T. In Mt. Forest township we pick it up again on the north line of section 35, the elevation there being from 624 to 634 feet A. T. On the north line of section 30, Pinconning, Mr. J. H. Blomshield made the height 636 feet at the top, where it is crossed by the so-called Pinconning stone road. This beach is also well developed in section 4 of Pinconning township, and thence northward along the Saganing road in Lincoln township, Arenac county. Mr. Lane has identified a beach at this elevation in the "Thumb," but it has not yet been given any name that I am aware of. On account of its fine development on the Saganing road in Lincoln township, Arenac county, I would suggest that the name Saganing beach be given to designate it. Mr. Blomshield made the elevation there on the north line of section 32, T. 18 N., R. 4 E., from 629 to 634 feet A. T., at the top and bottom.

In connection with the remarks made on the Saganing beach, we have had occasion to notice in section 1 of Williams township the elevation of that beach there at a height of from 618 to 633 feet A. T. From here we have a sand belt extending southeast through Monitor and Frankenlust townships, with occasional sand ridges piled up at lower and lower elevations, as the top of the lake covered moraine decreases in height southward. In the north half of section 7, Monitor, there is a beach well developed for about three-fourths of a mile extending east-southeast across the section, the top of the beach having an elevation of 623 feet A. T. near the town line. In the northeast quarter of section 7, the beach swings in and drops off, making a kind of delta hook or spit toward the south. On the line between sections 7 and 8, there is only a low slightly developed shore line which gradually becomes higher toward the east and south, swinging around and falling off around the southeast corner of section 8. On the east and west quarter line of this section the crest of this beach is 624 feet high where it is crossed by the Huron and Western R. R. In this section, the beach faces all four points of the compass, but is higher on the north and east sides. The demarkation of this beach on the north side of the river clearly shows the extension of an inlet up the present valley at that time, on the northern shore line of which, the beach was deposited for a short distance to the westward. Again south of the river, in the S. E. ¼ of section 17, and in the N. E. ¼ of section 20, beach formation again took place at an elevation of from 611 to 621 feet A. T. In section 20 the beach is recessed by Culver creek which flows more or less parallel to the trend of the sand ridge, northeast, forming a subordinate inlet of the lake shore at that time. Again to the southeast and across the course of Culver creek, the elevation of a slightly developed ridge on the Midland stone road, and just east of the west quarter post of section 21, is or was, 605.93 A. T., as determined by Wm. Mercer in 1865, while running levels for the Bay City and Midland Plank road. In the S. W. ¼ of section 21 the elevation increases locally to about 616 feet A. T. South and east of here the beach is irregularly developed in sections 27, 34 and 35, Monitor. The top is at an elevation of about 605 feet and may be considered the southern extension of the Algonquin beach, as developed in the south part of West Bay City to the eastward. This beach extends south and somewhat east through Frankenlust township, leaving Bay county a short distance west of the southeast corner of section 14. The elevation in Frankenlust is generally from 590 to 600 feet A. T.

During the period when these, at least in part, morainal beaches and perhaps an occasional delta formation were being formed in Monitor township, another shore line was being formed to the northward in the tier of townships adjacent to Saginaw bay, and west of the Algonquin beach. This beach immediately antedates the Algonquin sand ridge, and in general is from about 610 to 620 feet A. T. at the bottom and top. It is rather discontinuous. On the east line of section 19, Kawkawlin township, such a beach formation runs in a general easterly direction south of the river at an elevation of from 612 to 620 feet A. T. Other beaches having approximately the same elevation are found in the N. E. ¼ of section 17, on the line of section 16, and in the N. W. ¼ of 15 of the same township. In section 6 of Fraser township, there is rather a complicated beach and delta? and bar formation which meanders around in this section. A spur extending across the east line of said section 6, has an elevation of from 616 to 621 feet A. T. To the south, the valley of the Chute creek drain meanders east and west, south of the old shore line. Northward, this beach conglomeration is separated from a similar formation in section 31 of Pinconning township, by the valley of Mud creek. These two sand ridges north and south of Mud creek are almost counterparts of each other in that they swing in to the north and drop off before reaching the east line of sections 6 and 31, T's. 16 and 17 N., R. 4 E., forming, I believe, spit formations. In section 32 of Pinconning township, a spur increases in elevation eastward, until it swings around and drops off to the northeast, in the N. E. ¼ of the section. In the south half of section 2 Pinconning, and about one mile west of the Algonquin beach, there are similar beach formations with an elevation of from 607 to 616 feet A. T. The same may also be seen in the north half of the same section. During this state of lake elevation, delta formation seem to have been especially active, owing to the existence of numerous small streams which worked east down the land as the lake retreated. I believe that we also have off shore bars occasionally represented of considerable elevation and spurs due to wave action and shore currents.



THE ALGONQUIN CUT BEACH IN SECTION 33 OF MERRITT TOWNSHIP.



THE ALGONQUIN BEACH, SHOWING THE SHELF ABOUT HALF WAY DOWN. LOCATED NEAR THE EAST QUARTER POST OF SECTION 15, KAWKAWLIN TOWNSHIP.

5. *The Algonquin Beach.*

This is in all respects the most well marked and continuous beach formation in Bay county, extending with scarcely an interruption its entire length north and south. During the formation of its shore lines in the southern third of the county, beach formation ceased in the vicinity of Salzburg, south of West Bay City, and we have Lake Algonquin spreading out farther to the west, forming the shore line south of the Midland stone road as already described. During this period the lake extended at least as far south as St. Charles in Saginaw county, the valley of the Saginaw river and its tributaries forming a bay which was the extension of the present Saginaw bay to the southward.

East of the Saginaw river or estuary, in Bay county, the comparatively small amount of ground above the lake at that time was formed into an island extending northwest from near the center of section 33, Merritt township. This island may have originally been a water laid moraine. In this area east of the river, are the only clear indications of beach cuttings that I have yet seen in Bay county. This is well developed on the east and west quarter line of section 33, Merritt, where the cut beach has an elevation of from 597 to 602 feet A. T. The beach in the eastern part of the section here faces the east, swinging around to the west and north in this and section 32, from where it veers off to the north and west. North of section 33, the cut beach is less pronounced in section 28, and is represented by a built up sand ridge in section 18. On the west side a similar formation may be seen in section 19. On our soil map this cut beach line is represented by hachures. In the N. E. ¼ of section 3, Portsmouth, the west side of this cut beach is again finely developed at an elevation from 595 to 603 feet A. T., as determined by spirit level. The north and east shore line of the Algonquin is again developed in section 26 of Portsmouth, and thence westward into Bay City, where it may be seen at Washington Park and just south of there. In west Bay City the Algonquin shore line swings west of the Saginaw river, before finally terminating near Salzburg.

North from West Bay City, the Algonquin beach is followed by the East Saginaw and Au Sable road throughout almost its entire extent, to the Arenac county line. In Kawkawlin township, levels have been run along the top of the beach with the object of converting it into a stone road way. The eastern front of this beach in the east central part of Kawkawlin, shows a well marked shelf at an elevation of about 593 feet A. T., the height of the top and bottom of the beach being 587 and 610. I have taken this shelf as indicating the elevation of the water when the Nipissing ? beach was in process of formation there. Toward the Kawkawlin river, this beach increases in breadth going south, the eastern front swinging nearer the bay.

On the north and south banks of Michie creek, this beach swings to the east, but is more pronounced in its western trend on the north side of the stream. Apparently Michie creek follows a consequental drainage valley, which altered the course of beach formation here during this period.

6. *Nipissing Beach.*

In the remarks made concerning the Algonquin beach in the central part of Kawkawlin township, it was observed that the lower portion of the beach there had an elevation of from 587 to 593 A. T. In Hampton township, north of what I have correlated as the Algonquin beach, there is a well marked shore line extending east and west from section 34, T. 14 N., R.

5 E., with an elevation of from 587 to 598 feet A. T., or very nearly the same height as the lower portion of the Algonquin in Kawkawlin township. Do these two localities represent a beach united in one place and separated in another? East of the Algonquin the same beach is represented by a sandy area running north and south in the north half of Merritt township. This shore line may represent Taylor's Lake Nipissing, when Lake Huron had about its present elevation. West of Saginaw bay, we have a beach starting in the north half of section 24, Kawkawlin, T. 15 N., R. 4 E., and running parallel with the bay shore for about three miles northward.

The present beach of Saginaw bay is well developed along the shore line of Hampton township, at an elevation of from 580 to 587 feet A. T. East of the lower reaches of Tobico bay we have a sand formation 16 feet high, probably due to both wave and wind action.

7. *Distribution and Structure of Surface Deposits. Shell Beds.*

Adjacent to the beach lines above described, are considerable areas of sandy soil gradating into loam and gravelly deposits. These areas are printed orange yellow on the soil map, the thickness of the sandy beds being approximately indicated by increase or decrease in the amount of stippling, *i. e.*, the greater the amount of sand, the heavier the shading. Such sandy areas will be noted in the area adjacent to Saginaw bay, being bounded on the west by an area of clay soil, which increases in width toward the south, including the greater part of Monitor, Williams and Frankenlust townships. These clay areas have been left uncolored on the soil map. North of Williams township, the western tier of townships generally contain a greater or less amount of sand, in some places amounting only to a veneer of surface covering over the clay subsoil, which increases the ease of working, making it especially adapted for root crops. This is especially true of the soils in Gibson township, which produce fine crops of potatoes, hay, clover, etc. There are also areas in the western tier of townships where the clay comes to the surface in front of the beach lines, but they are of rather limited extent. East of the Saginaw river there are only limited areas occupied by sandy deposits, the greater part being clay with some muck land.

In connection with the remarks made on the drift and its subdivisions, we had occasion to notice some rather heavy beds of lake sands deposited in West Bay City, and adjacent to Saginaw bay. The following data obtained from drill records, will serve to give further information where we have beds of sand, for the most part adjacent to, or forming sand ridges. In sections 1, 2, 12, and 13 of Frankenlust township, we have from 2 to 20 feet of sand, as in the N. W. ¼ of section 13. Taking into account the elevation of the Algonquin beach here, and that of the clay beds in close proximity, it would rather seem that the sand was deposited in a swale. In sections 7 and 27 of T. 14 N., R. 4 E., we have from 5 to 20 feet of sand laid down in the area traversed by the sand belt running northwest through Monitor, forming a continuation of the Frankenlust deposits just mentioned. In T. 14 N., R. 5 E., we have from 3 to 33 feet of sand adjacent to the bay shore, and the Algonquin beach east and west of the Saginaw river. In the record showing the greatest amount of sand just north of the southeast corner of section 17, and near the crest of the Algonquin beach, we have some 15 feet more sand, than the elevation of the beach there. Also the bottom of the sand is lower than the adjacent surface clays to the northeast. In T. 15 N., R's. 4 and 5 E., east of the State road, and west of Sagi-

e have 17 drill holes for coal, which have from 6
tion 24, T. 15 N., R. 4 E. In the adjoining sec-
he drift varies from 7 to 19 feet in depth. In
nd 17 N., R. 3 E., we have three drill holes
d on the level, possibly delta or lake bottom

d areas in this county. In the south-
lerable areas of this soil either under-
nd separated on the map. Other
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East of the Saginaw
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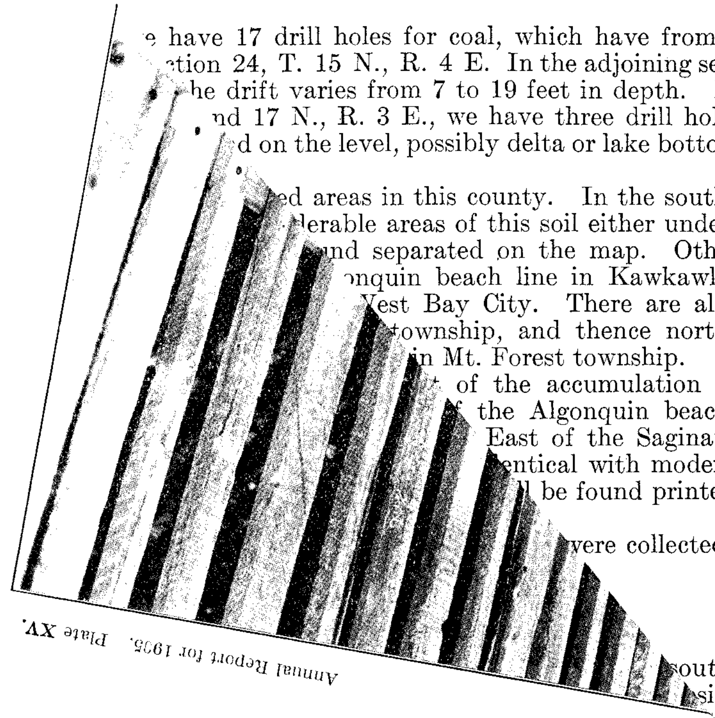

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GLACIATED ERRATIC IN THE NORTHWEST QUARTER OF THE NORTHEAST QUARTER OF SECTION 34, T. 14 N., R. 5 E.

naw and Tobico bays, we have 17 drill holes for coal, which have from 6 to 25 feet of sand as in section 24, T. 15 N., R. 4 E. In the adjoining sections to the north and east the drift varies from 7 to 19 feet in depth. In the lower portions of T's. 16 and 17 N., R. 3 E., we have three drill holes which show from 6 to 8 feet of sand on the level, possibly delta or lake bottom sands.

Muck land occupies rather restricted areas in this county. In the southeastern part of Merritt there are considerable areas of this soil either underlain by sand or clay, which will be found separated on the map. Other limited tracts are found west of the Algonquin beach line in Kawkawlin township, and west of the south part of West Bay City. There are also areas in the southwestern part of Williams township, and thence northward in the western tier of townships, especially in Mt. Forest township.

In Kawkawlin township this soil is the result of the accumulation of vegetable material in swamp land formed back of the Algonquin beach. These areas are printed in brown on our soil map. East of the Saginaw river these beds of muck often contain shell remains identical with modern species. A list of such species as I had time to collect will be found printed further on.

The following is a list of localities from which recent shells were collected with descriptions of the same.

Locality No. 1.

On the east line of section 23, Hampton township, and extending south from Nebobish avenue almost to the section corner, are interesting deposits of drift exposed on the west side of the road, and for the most part south of the Nipissing (?) sand ridge which crosses the section line there. Beginning toward the south, there are thin beds of stratified sand and gravel at the top from 10 to 20 inches in thickness and underlain by a bed of muck, which in turn rests on the clay. This bed of muck is formed south of the beach, and is very likely the result of former swamp formation during the Nipissing or late Algonquin epoch. Both the beds of stratified sand and gravel overlying the muck, and in the underlying clay are numerous shells which point to a lacustrine origin. There was probably considerable oscillation of the lake level during that time. Associated with the shell bearing beds were specimens of Devonian corals, which may have either been transported from the erosion of nearby deposits or carried a greater distance by floating ice. The specimens of shells from the underlying clay are considerably worn.

Locality No. 2.

Near the northeast corner of section 33, Monitor, is a depauperised fanua in a sandy loam deposit containing cobble stones. The shells are well preserved when found in the matrix, and do not indicate any action of the shore ice. During the Linear Survey, and to a lesser extent at the present time, this area was occupied by swamp land formed back of the Algonquin beach to the eastward. The elevation is about 601 feet A. T. These surface deposits are probably of Algonquin age.

Locality No. 3.

In a drain about three feet deep on the west line of the northwest quarter of section 7, T. 13 N., R. 5 E., I collected numerous specimens of shells in a silt clay, either of lake origin, or deposited more recently, by the river. The elevation is about 587 feet above sea level.

Locality No. 4.

Additional species were collected in a ditch from 12 to 18 inches deep, on the line between sections 9 and 10, T. 13 N., R. 5 E., and south of the quarter post. The deposit was clay containing small pebbles. Specimens were also seen in the same section further east. The elevation here is about 584 feet A. T. During the recent high water of the spring of 1904, this area was entirely flooded. This is on the border of the prairie region.

Locality No. 5.

This is on the north line of section 10, Merritt, and not far east of the northwest corner. In a drain which was being dug at that time, during the summer of 1900, there was exposed about four and a half feet of white sand at the top, underlain by a thin layer of muck above the clay. The section is not unlike that given in locality No. 1. This deposit may have been formed during the period of the Nipissing (?) lake. At any rate the elevation of this shell bed is quite approximately the same as in the first locality mentioned. As I remember, the sand beds here were deposited in a swale trending northward in the underlying clay. The muck probably represents a swamp deposit of Nipissing (?) age, or late Algonquin.

Locality No. 6.

These specimens were found in beds of muck and in the underlying clay, in a ditch on the west line of the N. W. ¼ of section 31, Merritt township. The elevation is from 586 to 588 feet A. T.

I have also seen shells in superficial sand deposits along an old tram road in the east half of section 34 of Gibson township, at an elevation of about 670 feet A. T. No collections were made here.

The following species were identified by Mr. Bryant Walker of Detroit with the exception of the Pisidia, and a few other species, which were sent to Dr. V. Sterki. The latter identifications are indicated by an asterisk placed before the species. An asterisk placed after the author of the species shows its occurrence in Huron county. Out of some 52 species identified in Bay county, 22 species are common to both localities.

Concerning the collection in general, Mr. Walker writes as follows: "With the exception of the new form of Pisidium from Monitor (Township—locality 2), there is nothing of special remark in this material. As a whole it is substantially the same as the existing fauna. There is some individual variation of course, but no more than would be expected in an equal amount of recent material; nothing so general and characteristic as to make a noticeable feature in the fauna."

The locality numbers used in this list correspond to those used in the text.

	1.	2.	3.	4.	5.	6.
Amnicola limosa Say*			*	*		
Amnicola lustrica Pils				*		
Amnicola walkeri Pils			*	*		
Bifidaria pentodon Say			*			
Calyculina securis Pme		*				
Campeloma decisa Say				*		
Campeloma integra Say						*
Goniobasis livescens Mke*	*		*	*	*	*
Limnaea caperata Say			*	*		
Limnaea catascopium Say*	*					
Limnaea desidiosa Say*		*		*		
Limnaea desidiosa, var. decampii, Streng*	*					
Limnaea humilis Say			*			
Limnaea palustris Mull*		*	*			
Limnaea reflexa Say*				*		*
Limnaea stagnalis Lea*						*
Physa elliptica Lea		*	*			
Physa gyrina, var. hildrethiana, Lea*	*			*		*
Physa heterostropha Say				*		
*Pisidium affine St	*			*		*
Pisidium compressum Pme	*		*	*		*
Pisidium contortum Pme		*				
*Pisidium medianum St				*		
*Pisidium rotundatum Pme		*				
*Pisidium sargenti St				*		
Pisidium scutellatum Sterki		*	*	*		*
*Pisidium splendidulum Sterki				*		
*Pisidium trapezoideum Sterki	*					
Pisidium variabile Pme	*	*	*			
*Pisidium ventricosum Pme		*				
*Pisidium ventricosum, var. costatum, St		*				
*Pisidium virginicum Bgt	*					
Planorbis bicarinatus Say*	*			*		*
Planorbis campanulatus Say*				*		*
Planorbis deflectus Say				*		*
Planorbis exacutus Say				*		
Planorbis hirsutus Ged			*	*		
Planorbis parvus Say*		*	*	*		
Planorbis trivolvis Say	*	*	*	*		*
Polygyra monodon Rack			*	*		
Polygyra multilineata Say				*		
Sedmentina armigera Say*			*	*		
*Sphaerium flavum Pme	*					*
Sphaerium occidentale Pme			*			*
Sphaerium simile Say	*			*		*
Succinea avara Say			*			
Succinea retusa Lea*	*	*	*	*		*
Unio gibbosus Bar*?	*					
Valvata sincera Say		*				
Valvata tricarinata Say*			*	*		*
Vertigo sp?			*			
Zonitoides minusculus Binn			*			

While these beds of sand, clay and muck containing shells represent late lacustrine deposits, it has not been found possible to systematically separate them from other argillaceous deposits in different parts of the county. Concerning the clay shell-bearing soils themselves I have not yet seen any beds above an elevation of 601 feet A. T., which are found described in locality 2. However, in the north half of section 23 of Kawkawlin township, I noticed a glacial erratic in the clay at about 587 feet A. T. Thus it will be seen that it is not possible to separate superficial lake clay deposits on account of the elevation of such beds. Also in section 31 of Merritt, glaciated erratics were found on the surface at an elevation of about 10 feet above the bay and Saginaw river or at 590 feet A. T. Mention has already been made of a buried glaciated boulder in the same section taken from the What Cheer shaft.

At other localities glaciated erratics have been found in a number of places. In the S. E. ¼ of section 31, Fraser, there is a small glaciated erratic at an elevation of 620 feet A. T. Likewise there are glaciated pebbles in section 29 of Pinconning. In Gibson township similar glaciated erratics were found in the west half of section 25, and in section 15. A granite boulder 10 feet long was found about three-tenths of a mile east of the north quarter post of section 22, Gibson township. Recently I noticed a fair sized glaciated erratic on the west side of the Algonquin shore line north of the stone road going east from the southern part of Bay City and west of the Tuscola stone road.

There are numerous erratics yet scattered over the surface of Bay county notwithstanding the extent to which they have been removed to facilitate tillage.

In the northwestern part of Williams township, the southern and eastern part of Beaver, the southeastern part of Garfield, and occasionally as far north as the central part of Gibson township, pot or kettle holes may be seen. In the northwestern part of Williams they are especially numerous. In form they are generally narrowly elliptical, the axis of the ellipse having a general north and south course. In such a pot hole a mastodon was found near the southwest corner of section 3, Williams, a notice of which appeared on page 253 of the annual report of the Geological Survey for 1901. The skeleton was buried three feet below the surface. The general formation and uniformity of these pot holes appears to be due to some general physical agency such as the ice. They may be due to the melting of buried ice masses or variation in the structure of the underlying soils producing the same result. Pot holes in general are supposed to have been produced by the accumulation of washed soils around bergs, which afterward melted, leaving an undrained hollow. The depth of water supposed to be on the surface of Bay county at that time rather precludes this explanation. To make this survey of the drift of Bay county fairly complete it only remains to be noted that drift corals of Devonian age have occasionally been seen on the superficial soil deposits of Gibson township.

CHAPTER V.

PHYSICAL GEOGRAPHY AND DRAINAGE.

1. *Introduction, Acknowledgements.*

In chapters 2, 3 and 4 we had occasion to investigate the geology of the Devonian and Carboniferous formations, and the coal and Quaternary deposits in greater detail, as they are developed in Bay county. The resultant of the processes which operated during that time, and the activities of physical agencies during the present, embrace the subject of physical geography as discussed in this chapter. In a sense physical geography is to geology, as physiology is to anatomy, the essential element being activity in its effect on geological deposits, as embodied in dynamic agencies. The agents as far as will be considered here, are the water, precipitation, the results and changes of temperature. These factors and the resultants of earlier geological conditions, enter largely into the relief of the surface of Bay county, now to be discussed. Hutton in his treatise on the "Theory of the Earth," 1803, was the first to recognize the importance of physical geography as a key to past geological results. Moreover, physical geography furnishes an explanation of many of the geographical features of Bay county, and I trust that this information will be useful to teachers in making their instruction more real, by the introduction of familiar illustrations.

In connection with this chapter I desire to acknowledge my indebtedness to Captain William Barrett, at that time Supervisor from West Bay City, who was the means of giving me access to the records in the County Drain Com--missioner's office. To the Drain Commissioner at that time, Mr. Lawrence McHugh, I am very glad to express my thanks for his generosity and accommodation. Additional drain records were obtained from Mr. J. Madison Johnston, who has been engaged in his profession of surveying for the last 40 years. Mr. John H. Kelly and Mr. Henry C. Thompson, former Drain Commissioners of Bay county, have both allowed me free access to their records, which have filled in a good many gaps. Mr. E. L. Dunbar, Superintendent of the Bay City Water Works Department, has given the Survey several valuable lines of levels. Mr. Dunbar also has the records of Mr. Wm. Mercer, former City Engineer of Bay City, which have been of very considerable use in the preparation of the contour map. The survey is especially indebted to Mr. John H. Blomshield, Engineer of the Bay County Bridge Commission, for the use of his office, and the numerous lines of drain levels which he ran for the most part about 20 years ago. Mr. Blomshield and Mr. H. C. Thompson have also run almost all the levels for the Bay county stone road Commission, of which I obtained almost complete records. Altogether the levels of 121 drain lines were obtained, along with the levels of 38 lines of streets, roads, and railroads. In this connection it would be well to emphasize the necessity of at least a certain amount of order, continuity and administration in the county drain work. As I believe the law demands, files showing the location, elevation and assessment of each drain are required to be on file in the County Clerk's office. As a matter of fact, not only are these records almost entirely lacking, but the levels of very nearly half the drains and most of the maps are or were, missing in the Drain Commissioner's office. This is probably due to the lack of permanent quarters for that department, which should be remedied. In the matter of drain assessments there was oft times, as the contour map shows, an almost total lack of justice, and while the contour map in this report may not always be sufficiently detailed and accurate, I believe that it will be of a very considerable use in this, as in other regards besides, as it has been in Ohio. I have endeavored to give the drainage area of all such drains as are enumerated. The expense of this report would be paid several times over if these data are properly used.

2. *Temperature and Precipitation.—Land and Water Temperature Variations.*

The mean temperature at Bay City is 46.3° F., or nine-tenths of a degree lower than for Saginaw. The maximum and minimum vary from 70.1° F. to 20.4° F., as in July and February respectively. The cumulative effect of the heat apparently manifests itself sooner than that of the cold, making the fall longer. In the accompanying table showing the mean temperature at Bay City, the average for certain missing months is given in brackets. These averages were obtained by first striking a monthly average of such records as we were able to obtain relative to Bay City. The differences of these averages at Saginaw was subtracted from the average of the month at the latter place, and taken as the mean for the missing month at Bay City. Additional tables were also prepared from the monthly reports of the Weather Bureau showing the maximum and minimum temperature of Bay City.

Mean Temperature at Bay City, Mich.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Average.
1896	......	......	......	50	63.6 63.9	65.8 67.2	70.5 70.7	68.3 69.3	57.0 57.4	45.0	37.2	38.2	....
1897	25.7	(25.1)	30.1	46.3	(54.6)	(62.3)	73.0	65.4	64.4	......	......	....	....
1898	25.0	25.8	35.4	41.2	56.2	66.5	70.2	68.2	64.1	49.4	(34.6)	25.7	46.4
1899	20.1	16.2	30.0	48.0	57.4	67.6	68.4	69.4	57.4	48.8	34.2	24.1	46.6
1900	25.4	17.6	23.0	45.8	57.2	65.0	70.4	74.4	65.3	53.8	41.2	26.6	46.4
1901	23.3	(15.3)	29.9	44.1	56.2	(66.8)	75.0	68.4	61.0	57.6	37.2	30.0	47.4
1902	24.6	(21.7)	38.2	44.7	56.8	62.2	70.8	65.0	59.9	50.8	32.9	21.8	45.4
1903	22.0	21.3	39.6	44.8	57.8	59.2	70.7	64.4	60.8	49.7	44.1	24.4	46.8
										51.6	33.6	21.1	45.6
Mean	23.7	20.4	32.6	45.3	58.2	64.7	70.1	68.1	60.8	50.8	36.9	26.5	46.3

Maximum and Minimum Temperature at Bay City, Mich.

Year.	January.	February.	March.	April.	May.	June.
1896	....	....	....	84, 19	89, 38 91, 39	89, 40 94, 42
1897	54, –6	....	....	73, 20	79, —	93, —
1898	40, –2	47, –12	62, 11	67, 16	78, 34	92, 44
1899	53, –13	51, –21	55, 12	86, —	82, 35	91, 45
1900	48, –7	62, –12	49, –4	80, 22	85, 28	92, 40
1901	44, 1	—, —	57, 0	84, 23	82, 32	—, 35
1902	54, 2	—, –2	68, 6	82, 22	89, 23	87, 40
1903	46, 0	42, –12	74, 13	85, 19	85, 24	88, 35

Maximum and Minimum Temperature at Bay City, Mich.

Year.	July.	August.	September.	October.	November.	December.
1896	92, 48 94, 48	94, 42 96, 43	84, 28 84, 29	74, 20	66, 9	52, 3
1897	100, 53	87, 44	95, 34	78, 31	—, 14	55, –8
1898	94, 42	93, 47	93, 36	84, 26	67, 13	44, 3
1899	89, 50	94, 47	91, 26	85, 28	60, 26	57, –7
1900	96, 45	99, 51	91, 38	87, 29	68, 20	50, 10
1901	98, 52	91, 48	90, 34	80, 25	60, 9	55, –8
1902	91, 48	85, 47	83, 38	71, 27	68, 19	44, –2
1903	95, 40	85, 40	90, 33	75, 25	70, 12	40, 1

The average amount of precipitation is about 34 inches, the annual variation between 1896 and 1903 inclusive, being from about 29 to 44 inches, as in 1900 and 1902 respectively. The greatest amount of rainfall is during July, with the least in February. Traces of snow come in October, and rarely as late as in May, the greatest amount falling in February when the rain precipitation is least. The average amount of annual snowfall was nearly 28.9 inches during the years 1896-1903, inclusive, varying from 12.5 to 36.2 inches during the years 1900 and 1902 respectively. Inasmuch, however, as our annual averages divide the winter into unequal parts the entire amount of snowfall would be changed somewhat. The following tables exhibit the entire amount of precipitation.

Rain and Snowfall at Bay City, Mich.

Year.	January.	February.	March.	April.	May.	June.
1896	....	....	....	2.54, ...	4.40, ... 3.52, ...	1.49, ... 1.26, ...
1897	3.70, 6.0	0.61, 5.8	4.26, 14.0	3.61, T	3.65, ...	0.64, ...
1898	2.57, 17.0	....., ...	3.52, 0.0	1.92, T	2.34, ...	4.53, ...
1899	1.93, 4.0	1.10, 2.5	3.02, 27.5	1.21, ...	4.72, ...	1.91, ...
1900	1.49, 3.2	2.94, 15.5	1.39, 9.0	2.07, 3.0	2.56, T	1.43, ...
1901	1.15, 7.5	....., ...	3.25, 3.0	1.05, 2.0	2.35, ...	0.85, ...
1902	0.08, 0.8	0.43, 3.5	6.09, 1.0	1.11, T	4.32, ...	6.50, ...
1903	1.53, 6.0	2.55, 17.0	1.26, T	4.77, T	1.95, ...	2.40, ...
Average	1.78, 6.4	1.53, 8.5	3.25, 7.8	2.36, 0.6	3.31, ...	2.33, ...

Rain and Snowfall at Bay City, Mich.

Year.	July.	August.	September.	October.	November.	December.	Total for year.
1896........	2.10, ...	2.75, ...	4.65, ...	0.58, ..	3.12, 2.0	0.71, 3.5	....
	0.74, ...	3.05, ...	4.24, ...				
1897........	10.10, ...	1.16, ...	0.69, ...	3.24, ...	2.30, T	2.15, 8.2	36.11, 34.0
1898........	1.38, ...	2.96, ...	1.97, ...	4.56, T	2.59, 8.0	1.46, 6.0	29. 8, 31.0
1899........	7.04, ...	0.22, ...	3.73, ...	4.73, ...	1.76, ...	1.95, 2.7	33.32, 36.7
1900........	4.65, ...	4.88, ...	1.27, ...	3.57, ...	2.97, 5.5	T T	29.22, 36.2
1901........	4.38, ...	4.57, ...	0.23, ...	4.10, T	0.85, T	1.90, 4.0	24.68, 16.5
1902........	8.46, ...	2.55, ...	4.10, ...	4.38, ...	2.44, 1.2	3.18, 6.0	44.14, 12.5
1903........	0.60, ...	7.25, ...	8.05, ...	3.90, ...	1.95, 3.5	1.45, 9.0	37.66, 35.5
Average.....	4.38, ...	3.26, ...	3.24, ...	3.63, ...	2.24, 2.5	1.60, 4.9	33.56, 28.9

Land and water temperature variation. An examination of the yearly mean isothermal lines for lower Michigan as given in the Michigan Section of the Climate and Crop Service of the U. S. Weather Bureau, in co-operation with the Michigan State Weather service, affords some suggestive comparisons. We have for instance, prepared the following table showing the higher latitude of the isotherms on the west shore line of lower Michigan, as compared to the east, for the years 1900-1904 inclusive.

Year.	Degree.	Miles farther north on west shore.
1900........	48	10
1900........	46	20
1901........	46	31
1901........	44	60
1902........	48	1
1902........	46	52
1902........	44	60
1903........	46	108
1903........	44	66
1904........	44	54
1904........	43	30
1904........	42	42
1904........	41	78
1904........	40	40

From this data we see that the isotherm of 48° has an average distance of six miles further north on the west shore than on the east; that of 46° of 53 miles; of 44°, 60 miles; of 42° and 40° for the year 1904, of 42 and 40 miles respectively. An average of these combined data show the same temperature averages extending 46 miles more northward on the west side of lower Michigan.

As an exception to this general rule of higher isothermal lines on the western shore of lower Michigan, the isotherm of 48° for 1903 is eight miles farther north in Macomb county adjacent to Lake St. Clair, than where Van Buren county is washed by the waters of Lake Michigan. Likewise during 1904, the line for 45° is 16 miles farther south in Berrien county, than in Macomb. Both these isothermals, however, show some deflection to the northward, on approaching the Lake Michigan shore.

Comparing the isothermals on the east and west sides of Lake Michigan, as given in the reports of the Section Directors of Michigan and Wisconsin, we obtain the following results:

Year.	Degree.	Miles farther south in Michigan.	Miles farther north in Michigan.
1900........	48	5	....
1900........	46	....	38
1900........	42	....	25
1901........	48	23	....
1901........	46	....	16
1902........	48	26	....
1902........	46	....	50
1903........	46	....	100
1903........	44	....	88
1904........	44	4	....
1904........	42	....	33

Taking into account the negative factor in this comparison, the results show the average temperature on the east side of the lake 36 miles farther north than in Wisconsin. None of these results compare very closely with those given by Alexander Winchell in Walling's atlas. The object of this section is to present some data showing the cause of this atmospheric variation. In obtaining our temperature observations I used an H. J. Green thermometer No. 7529. The readings were taken on the west side of Saginaw bay and east of Tobico inlet, northwest of Bay City. Less than five minutes elapsed between the readings on the land and in the water. During August 12, 13, 15, 16, 17, and 18, 1904, the thermometer was read at 5:30, 7:30-10:30 hourly, and at 11:15 A. M., and hourly from 1:00 to 7:00 P. M., excepting at 6:00 P. M. August 22 and 23 readings were taken consecutively from 1:00 P. M. to 11:15 A. M. the following morning. August 25 and 26 the thermometer was read from 5:30 A. M. to 5:30 A. M., being consecutive for 24 hours ending August 26. Judging from the last two series of observations the maxima and minima temperatures were very nearly obtained by the readings taken from 5:30 A. M. to 7:00 P. M. Our land and water temperature at Tobico will be compared with the maxima and minima readings taken by the Weather Bureau at Bay City, Midland, Saginaw, and Hayes. From Tobico, Bay City is situated six miles to the southeast, Midland 16 miles west and somewhat south, Saginaw 19 miles almost due south, Hayes 36 miles east-northeast across Saginaw bay. These readings can be most conveniently presented by tables

Maximum and Minimum, August 12, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
80..............	80	80	78	79	73.5
48..............	58	48	44	51	68.0
32..............	22	32	34	28	5.5

The variation of water temperature at Tobico compared with the land is 19%. The winds were light and variable. The average of my land temperatures on the day in question was 71°, of the water 72°.

Maximum and Minimum, August 13, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
77	78	87	82	80.5+	71+
47	58	63	61	66	68
30	20	24	21	14.5	3

The day was cloudy until 9:30 A. M. Our readings ceased at 11:15 A. M. The air temperature at Tobico increased 14.5°; that of the bay 3° or 20.7%. The average of the six readings taken during the forenoon was 71.6° for the land, and 68.9° for the water. The wind at Saginaw and Midland was from the southwest; from the north at Bay City.

Maximum and Minimum, August 15, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
86	76	89	86	83	74
63	52	66	59	62	67
23	24	23	27	21	7

The day was clear with westerly winds blowing. From 5 A. M. to 2 P. M. the Tobico water temperature increase was 33% of that of the land. Locally the result in modifying the temperature at Tobico is somewhat apparent, but we would rather expect the variation at Midland and Hayes almost reversed.

Maximum and Minimum, August 16, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
81	70	83	78	79.7	77.0
60	....	61	56	62	69
21	20	22	22	17.7	8

It rained during the night of August 15 and 16, clearing up by noon time, the wind apparently being down the bay, or from the northeast during the period of fair weather. At Bay City, Midland and Hayes the wind was from the northwest; from the southwest at Saginaw. The water temperature increased 45% of the range of the air. This very considerably higher ratio of the water is very likely due to the action of the wind sweeping down the bay, exposing relatively a larger water surface to the wind within a unit of area, and to the action of the waves in entrapping particles of air. Not having the temperature of the rain water which fell during the night it is impossible to state how this would modify that of the water in the bay. The water temperatures during the day only dropped 3° from 7:00 P. M. to 5:30 A. M. the next morning, while that of the land fell 9° in the same interval.

It is apparent that under such conditions we would have the climate somewhat modified, the main tendency being to check sudden variations near the adjacent windward shore, and to increase the temperature, especially at night. With the exception of Midland the land temperatures increase going away from the bay. The highest minimum temperature is adjacent to the shore as we should expect; away from there it is irregular as can be seen from the table. Our average land temperature at Tobico was 71.25°, of the water 73.07°.

Maximum and Minimum, August 17, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
75	74	82	?	80	77
60	50	60	?	62	71
15	24	22	....	18	6

This day was clear with the wind at Tobico from the west during the greater part of the forenoon, and shifting to the north at 1 P. M. At Bay City the wind was from the northeast, at Saginaw from the southwest, and from the west at Midland. The increase of water temperature was 33% of the range of that of the air at Tobico, being somewhat intermediate between periods when the wind is off and on shore. The main trend of the bay is northeast. It is apparent that this northerly wind was quite pronounced in ameliorating the temperature of Bay City, which is situated directly south of the bay about two miles, and more nearly in the path of the wind than our station at Tobico. It is also noticeable that at Saginaw some 14 miles further south, the benefit is much less apparent. The still greater amount of variation at Midland is apparently explained by its location and the westerly breeze blowing there. These on-shore winds are only pronounced in modifying climatic conditions within relatively circumscribed areas. This deduction is not only bourne out in part by our own data, but by an examination of the isothermal charts of lower Michigan for 1903 and 1904, to which we have already had occasion to refer. An average of 12 readings on land and water, gives 72.8° for the former, and 73.9° for the latter, at our stations near Tobico bay. Also I believe that an examination of the observations for August 17, and other sources of information, show that insular climates are more pronouncedly influenced in preventing minima temperatures, than the reverse. This is especially true in the late summer and fall. In the spring and early summer we would expect the reverse. As to the former conclusion, as we shall see farther on, this is due to the very considerable capacity water has of absorbing heat during the day and retaining the same to a greater capacity at night.

Maximum and Minimum, August 18, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
75	78	78	80	75.2	75.3
58	60	59	45	57.0	66.0
17	18	19	35	18.2	9.3

During this day the sky was clear with an easterly wind blowing on shore at Tobico; at Bay City and Saginaw from the northeast, at Midland from the northwest. The Weather Bureau record at Hayes is wanting in this respect. It will be noted from the above tables, that the temperature range of Saginaw bay increased 50% of the air. Comparing this with those previously discussed, it was noted that with a north wind blowing diagonally across the bay, that the ratio of water to land temperature was 33%, with a northeasterly wind blowing down the bay of 45%, while that from the east, as just given, is 50%. While theoretically we might expect the greatest increase of water temperature with a full breeze coming from the northeast down the main trend of the bay, this result is very probably modified by the shallow waters of the lower reaches of Saginaw bay, giving greater play to wind action. This on shore action, as noted above, is not only pronounced in increasing relatively the greater warmth of the water, but also, *pari passu,* in modifying proportionately that of the adjacent land to the west. It is also true that this modification of temperature would be greater during the night on account of the greater radiation of the heat from the land. The result at Hayes, compared with Midland, is especially noticeable in variation of temperature at the former place, probably due to this easterly wind.

Maximum and Minimum, August 22, 23, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
75 45	78 58	78 44	83 45	76 50	74.5 66
30	20	34	38	26	8.5

During portions of these two days observations were taken consecutively from 1:00 P. M. to 11:15 A. M. Our maxima readings were taken August 22, minima readings the following morning. The weather was clear, wind from the northwest, shifting to the west at about 7 A. M., August 23. At Bay City and Midland the wind blew from the southeast and south, at Saginaw from the southwest. During this time the variation of water temperature compared to that of the air was 32.6%. During the forenoon of the 23d the air temperature increased 24° by 11:15 A. M., and the water increased 5.7° within the same time, or 23.75%. While during the afternoon the maximum air temperature was 1.8° greater than the water, at 5:30 A. M. the next morning the lowest air temperature was 16° less than the minimum water temperature, showing the very considerable capacity of the water to retain heat during the night, and the ameliorating result that it would have on the land with an on shore wind blowing. An average of our air and water temperatures near Tobico are respectively 64.5° and 69.9° during the entire period of about 24 hours.

Maximum and Minimum, August 25, 26, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
83 44	80 60	82 43	80 ?	85 46	75.5 63.3
39	20	39	....	39	12.2

During the 24 hours ending at 5:30 A. M., August 26, 1904, we have a continuous series of air and water temperatures. At Tobico the weather was fair, with quite a strong westerly wind blowing throughout that time. At Bay City, Midland and Saginaw, the wind was also from the west and southwest. Our maxima readings were taken on the 25th, the minima on the 26th. The average of 18 readings give an air temperature of 67.07°, that of the water being 69.9° for the same time. During the 25th the air and water temperatures increased 13° and 7.5° respectively, the ratio being 57.6%, followed by a minimum drop of 39° and 12.2° of the air and water at 5 A. M. on the 26th of the following morning, or only 31% of change of the water relative to the air. Air and water temperatures taken simultaneously on the other side of the bay would be desirable for comparison here. These readings, however, clearly show the property water has of absorbing and retaining heat.

In the period which is covered by our observations the average of water temperature was 72.11°, that of the air being 72.38°. It is more probable, however, as shown by our readings for 24 hours, that the average water temperature is about 4° greater during the latter part of August than that of the air. The ratio of change of water temperature relative to that of the air is less than 34.4%. In this factor, taking into account the prevailing southwesterly winds, is at least a partial explanation of the insular climate of lower Michigan. Moreover, the temperature of the water, as a rule, being greater than that of the air from about 7 o'clock in the evening until about 9 o'clock the following day, the tendency would be to increase the temperature of the adjacent shores. On the other hand, the air temperature being greater during the remainder of the day, the water would tend to establish an equilibrium negatively, the two means of variation probably approaching that of the average of the two factors, air and water. The more prolonged period of greater water temperature is doubtless the greater factor in this question.

The following tables are appended showing the maxima and minima temperatures of West Saginaw, Bay City and Midland, as furnished by C. F. Schneider of the State Weather Bureau, with our own observations near Tobico.

1904.	Aug. 12.		Aug. 13.		Aug. 15.		Aug. 16.		Aug. 17.		Aug. 18.		Aug. 22.		Aug. 23.		Aug. 25.		Aug. 26.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Bay City	80	48	77	47	86	63	81	60	75	60	75	58	75	....	....	45	83	....	....	44
Midland	80	58	78	58	76	52	70	50	74	50	78	60	78	....	....	58	80	....	....	60
Saginaw	80	48	87	63	89	66	83	61	82	60	78	59	78	....	....	44	82	....	....	43
Hayes	78	44	82	61	86	59	78	56	....	....	80	45	83	....	....	45	80	....	....	....
Tobico	79	51	80.5+	66	83	62	79.7	62	80	62	75.2	57	76	....	....	50	85	....	....	46
Saginaw bay	73.5	68	71+	68	74	67	77	69	77	71	75.3	66	74.5	....	....	66	75.5	....	....	63.3

Air and Water Temperature near Bay City.

1904.	Aug. 12.		Aug. 13.		Aug. 15.		Aug. 16.		Aug. 17.		Aug. 18.		Aug. 22.		Aug. 23.		Aug. 25.		Aug. 26.	
	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.
1:00 A. M.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	53	67.3	....	....	48	65
3:00 A. M.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	51	66.5	....	....	46	64
5:00 A. M.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	46	63.3
5:30 A. M.	51	68	66	68	62	67	62	69	62	71	57	66	....	....	50	66	72	68	46.5	64
7:30 A. M.	64.5	69	69.3	68.3	66.2	68.6	65	69	67.4	71.3	65.4	68	....	....	61	67	76	70	....	....
8:30 A. M.	....	....	69	68.5	71	71	62	69.3	72.5	72.5	65.5	68.6	....	....	69	68	79	71.5	....	....
9:30 A. M.	72.5	71	71.4	69	73.5	73	66.3	70.3	76.2	73.6	70.5	69.8	....	....	69.5	69	79	72.5	....	....
10:30 A. M.	....	....	73.5	....	73.5	73	68.2	71	78	75	69.3	72.2	....	....	72.5	70.4	79	72.5	....	....
11:15 A. M.	74	73.5	80.5	71.0	73.3	73.3	72.7	72	80	76	75.2	74	....	....	74	71.7	80.5	73.4	....	....
1:00 P. M.	78	73.6	....	....	83	74	79.7	75.6	79	77	73.3	74.8	73	73.2	....	....	85	75.3	....	....
2:00 P. M.	78	73.3	....	....	81.6	74	76.2	76.5	78.6	76	73.4	75.3	75.5	74.5	....	....	79	75.1	....	....
3:00 P. M.	79	73.5	....	....	....	....	76.3	77	74.8	75.5	73	75	76	74.2	....	....	78.2	75.5	....	....
4:00 P. M.	78	73.5	....	....	79	74	76.6	76.5	72	74.3	73	74.1	74.2	73.6	....	....	74.1	74.5	....	....
5:00 P. M.	76	73.5	....	....	84	73.3	79	76.5	68.2	73.2	72	73	72.6	72.6	....	....	70.5	73.5	....	....
6:45-7:00 P. M.	71	71.6	....	....	71.5	73	71	74.1	65	71.1	68	71	62.6	71	....	....	63	69	....	....
9:00 P. M.	....	....	....	....	....	....	....	....	....	....	....	....	59	69	....	....	55	66.5	....	....
11:00 P. M.	....	....	....	....	....	....	....	....	....	....	....	....	55	68	....	....	50.5	66	....	....
Average	71	72	71.6	68.9	74.4	72.2	71 25	73.07	72.8	73.9	69.7	71.8	....	....	64.5	69.9	....	....	67.07	69.9

The prevailing winds in Bay county, as in the greater portion of the United States, are from the west and southwest, but they are modified in this region by the usual breezes from Saginaw bay. It was quite often noticeable that in the evening after the wind had been blowing from the west throughout the daytime, a breeze would spring up from the bay and continue to blow as long as the radiation from the land caused the heated air to rise. After an equilibrium had been established the breezes would die out again.

Mr. W. T. Shaw found in several places along the shore of Saginaw bay north of Kawkawlin, the meander posts of the Linear Survey at the water line, as near as it is possible to define this line in the swampy region which is generally characteristic of the west shore of the bay. It would thus seem that erosion has modified but very slightly the topography of the shore line of Bay county, since the time that survey was made.

3. *Elevation of Saginaw Bay and Lake Huron.*

By the levels of 1877 of the U. S. Lake Survey the high water mark of 1838 is given as 584.34 feet above the mean tidal elevation at Governor's Island in New York harbor. In the report of Huron county by Mr. Lane, and in this report, this determination has been used as the most accurate then available. More recent results, based on a more perfect determination by the U. S. Lake Survey, and levels of precision run by the U. S. Coast and Geodetic survey, increases the elevation of the high water mark of 1838 by .35 of a foot, making the elevation 584.69 feet A. T.

At Bay, and West Bay City, I have had some trouble in attempting to coordinate the results of different lines of leveling. The elevation of the zero of the government gage at the front Light House crib of the Saginaw river range is given as 580.25 feet A. T. This is the result of comparison

of 29 monthly means with corresponding ones at Harbor (Sand) Beach, Lake Huron. The U. S. Government also has a gage located on the Third or Midland Street bridge connecting Bay and West Bay City. The elevation of the zero of this gage is stated by the Engineers of the War Department as 583.75, but as we shall see, this is not within the limits of possibility. During the late summer of 1902 the light house keeper and I compared the gage elevation at the mouth of the river, and at the Third street bridge simultaneously on a quiet day, and found the zero to tally within less than 0.1 of a foot lower. It has been assumed, therefore, that the zero of both gages are approximately the same.

During the winter of 1902-3, Mr. E. L. Dunbar, Supt. of the Bay City Water Works, very accommodatingly ran a line of levels connecting the zero of the Third Street gage with the Bay City datum at the northwest corner of the water table of the Fraser House. The elevation of the local city datum is 50.00, and according to Mr. Dunbar, is 13.09 feet above the zero of the Third street bridge. This would make the elevation of the city datum 593.34 feet A. T. This elevation was used for all lines of levels connected with the Bay City bench mark. Mr. John H. Blomshield and R. R. McCloy of Bay City have also run levels connecting the zero of the Third street bridge with the city datum of Bay City and of West Bay City, which is based on the elevation of the former city. These levels tally within .007 of a foot, Mr. McCloy's levels being that much higher. Mr. McCloy is of the opinion that the amount of error in reading this gage, which is inconveniently situated, is not more than .05 of a foot. The result of these two surveys is to make the elevation of the Bay City datum 13.18 feet above the zero of the Third street bridge. As will be seen, this is .09 of a foot higher when compared with Mr. Dunbar's result. Mr. McCloy's levels were run for the survey August 30, 1902. The elevation of the West Bay City datum from the same survey would give a local elevation of 59.39 feet for the water table at the southwest corner of the Loose Block. This would be 602.82 feet above tide. Using this determination I have obtained the elevation of a line of levels which was run by Mr. Blomshield from the Loose Block along Henry street to Saginaw bay. This line would make the elevation of the bay, May 18, 1899, 579.99 feet A. T. The elevation of the Harbor beach gage for that month was 579.96 feet. The only accurate determination of the elevation of the gage at the Third street bridge is to connect it by a line of levels with the gage at the mouth of the river.

4. *Tilting of the Great Lake Basin.*

In Mr. Lane's report on Huron county[1] and in the "Michigan Miner" for June 1, 1900, there are references to this important determination by G. K. Gilbert of the U. S. Geological Survey. The result of Mr. Gilbert's investigation apparently shows that the land is rising to the northeast at a rate that would produce an apparent fall of the lake in Huron county of 0.2 foot per century. It is only intended here to bring together all local references which may be of use to future investigators.

Mr. E. L. Dunbar made the elevation of Saginaw river June 21, 1888, 39.481; March 23, 1888, 37.73; April 9, 1888, 37.65; of Saginaw bay on April 19, 1888, 37.974; April 21, 1888, 38.151; April 23, 1888, 38.037. These elevations are all in reference to the Bay City datum at the Fraser House, as defined above. We have already had occasion to refer to Mr.

[1] Geological Survey of Michigan, Vol. VII, part 2, p. 35.

Blomshield's elevation of Saginaw bay on May 18, 1899, when the height was 36.56 C. D. Additional data from the same authority are as follows: June 10, 1899, 36.77; Nov. 22, 1900, 36.025. This latest elevation was made with especial care for the Geological Survey on a still day. It is hardly necessary to add that these elevations of Mr. Blomshield are connected with the Bay City datum as determined by him and Mr. McCloy.

Assuming that the elevation above tide for the Bay City datum is 593.43, as determined by Blomshield and McCloy in August, 1902, it remains to be seen whether there has been any appreciable elevation of Bay City since Mr. Dunbar's determinations in 1886 and 1888. Inasmuch as Bay City is nearer the nodal line of stability than Harbor Beach, it is not to be expected that the amount of elevation could exceed .032 foot in the period from 1886 to 1902.

5. *Fluctuations of Mean Lake Level.*

These may be divided into three main classes. 1. Local fluctuations due to the direction of the winds, and variation in barometric pressure; 2, annual fluctuations and slight tidal elevations; and 3, variations in lake elevation of greater period which show the cumulative effects of rainfall of the previous years. These latter have been very instructively brought out in Plate V of the Huron county report.

The prevailing winds being from the southwest, with occasional storms from the northeast, the trend of Saginaw bay is peculiarly adapted to show results of the piling up or recession of the water. These results are enhanced by the shallowness of the bay, the depth with the exception of a local depression just south of the Big Charity Islands, gradually shelving off to a maximum depth of 9.5 fathoms or 57 feet.

In the survey chart of Saginaw bay issued by the U. S. Lake Survey, it is stated that during the prevalence of strong winds from the northward and northeast, the average increase of depth was observed to be seven inches and the maximum 15 inches. During the prevalence of strong winds from the southward and southwest the average decrease in the depth was by observation found to be two inches and the maximum eight inches. Along the same line, the observations of Mr. John H. Blomshield are worthy of record. During a storm from the northeast in the spring of 1899 the local elevation increased about 4.48 feet. On December 12, 1899, a strong south wind lowered the elevation of the bay 2.71 feet. The total amount of difference amounts to 7.19 feet. All these observations tend to show that the piling of the water due to the northerly or northeasterly winds is more pronounced. This is very likely due, to the shore line at the southern extremity of the bay which produces a damming effect not obtainable in the main body of Lake Huron. The extreme amount of variation in elevation is perhaps not surprising. Wm. T. Blunt, U. S. Ass't. Engineer,[1] has shown that in a severe westerly gale, the west end of Lake Erie lowered the water from seven to eight feet. The reader is referred to that report for further details of this interesting subject.

Annual and periodic fluctuations in the elevation of Lake Huron are considerably elaborated by Mr. Lane in his Huron county report.[2] The subjoined table taken from the report of the U. S. Deep Waterways Commission, and brought up to date from records furnished the survey by Major W. L. Fisk of the U. S. Lake Survey, will suffice to give an accurate idea

[1] Report of the U. S. Deep Waterways Comm., 1896, p. 155.
[2] Volume VII, part 2, p. 37.

of the annual and periodic elevation of Saginaw bay and Lake Huron. In general the annual maximum of high water in June or July is due to the melting of the winter snows and spring rains. The lowest water is in the latest winter months, when the ground freezes and the rain changes to snow.

6. *Table Showing the Fluctuations in Lake Huron.*

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1819	....	6.67	....	....	....	4.67	....	....	....	....	....	....	....
1828	....	....	....	....	....	1.84	1.78	1.84	....	....	....	....	....
1830	....	....	....	....	....	1.84	....	....	....	....	....	....	....
1836	....	....	4.00	....	....	1.00	....	....	....	....	....	....	....
1837	....	....	....	....	3.20	0.59	....	....	....	....	....	....	....
1838	....	....	....	....	....	(0.00)	0.00	....	....	....	....	....	....
1839	....	....	....	....	....	....	1.33	....	....	....	....	3.67	....
1840	4.50	....	....	3.07	2.96	2.88	2.62	(2.88)	3.23	3.38	3.56	3.79	....
1841	3.71	....	....	....	....	....	....	....	....	....	....	4.43	....
1845	....	....	....	....	....	3.50	....	....	....	....	....	....	....
1846	(4.40)	4.42	4.27	3.79	3.43	3.44	(3.38)	3.65	4.13	4.38	4.66	5.03	4.08
1847	5.38	5.50	5.28	5.19	4.98	4.57	4.51	4.56	4.45	4.77	4.88	5.09	4.93
1848	5.29	5.34	c 5.35	5.00	5.30	5.05	4.47	4.46	4.64	4.72	4.82	4.77	4.93
1849	4.80	4.70	4.90	(4.70)	(4.60)	(4.05)	(3.75)	3.75	....	....	....	....	....
1851	....	....	....	....	....	....	2.57	2.30	....	....	b2.43	....	....
1852	....	....	....	....	....	....	....	1.50	2.02	2.10	1.96	....	....
1854	....	....	....	3.70	3.05	(2.78)	(2.46)	(2.50)	2.61	3.18	3.45	3.53	....
1855	3.79	(3.82)	3.75	3.67	3.10	2.77	2.68	2.57	2.48	2.61	2.81	2.71	3.06
1856	2.65	3.14	3.12	2.99	2.56	2.63	2.56	2.75	2.87	3.06	3.12	3.35	2.90
1857	3.55	3.27	(3.14)	2.68	2.33	2.03	1.60	1.41	1.56	1.49	2.30	2.26	2.30
1858	2.33	2.62	2.70	2.18	1.70	1.28	0.89	0.93	1.33	1.48	(1.81)	1.79	1.75
1859	2.28	2.15	2.09	1.45	1.30	1.30	0.65	0.95	1.19	1.52	2.02	1.95	1.57
1860	2.02	2.07	1.93	1.96	1.91	1.67	1.58	1.66	1.85	2.23	2.35	2.65	1.99
1861	2.86	2.82	2.68	2.48	1.86	1.52	1.40	1.29	1.37	1.59	1.90	2.03	1.98
1862	2.41	2.42	2.51	2.30	1.93	1.81	1.76	1.78	2.00	1.72	2.04	2.33	2.08
1863	2.49	2.64	2.69	2.62	2.30	2.17	2.26	2.25	2.39	2.65	2.69	2.92	2.51
1864	3.06	3.10	3.10	2.90	2.47	2.46	2.51	2.62	2.94	(3.47)	(3.64)	(3.77)	3.00
1865	4.13	4.04	3.87	3.38	3.22	3.18	2.75	2.73	2.85	3.09	3.65	3.96	3.40
1866	4.22	4.46	4.41	3.96	3.78	3.49	3.23	3.17	3.32	3.43	3.52	3.78	3.73
1867	3.80	3.75	3.57	3.28	3.06	2.75	2.60	2.67	2.94	3.27	3.73	4.08	3.29
1868	4.24	4.28	3.60	3.70	3.42	3.21	3.18	3.52	3.76	3.99	4.06	4.34	3.78
1869	4.44	4.37	4.63	4.26	3.93	3.40	3.02	2.76	2.87	3.23	3.35	3.63	3.66
1870	3.57	3.48	3.18	2.76	2.42	2.28	2.17	2.26	2.12	2.52	2.92	3.27	2.75
1871	(2.83)	(2.91)	(2.31)	(2.11)	(1.76)	(1.72)	(1.69)	2.29	2.61	3.11	3.32	3.69	2.53
1872	3.86	4.06	(4.17)	4.14	3.74	3.34	3.24	3.27	3.37	3.49	3.79	4.08	3.71
1873	4.25	4.28	4.21	3.80	3.30	2.90	2.70	2.69	2.86	2.89	2.99	3.15	3.34
1874	3.13	2.99	2.85	3.00	2.95	2.61	2.45	2.56	2.72	2.96	3.23	3.48	2.91
1875	3.69	3.75	3.71	3.52	3.17	2.86	2.67	2.70	2.66	2.85	2.96	3.23	3.15
1876	3.11	3.13	3.00	2.72	2.12	1.63	1.19	1.25	1.36	1.76	1.91	2.10	2.11
1877	2.39	2.40	2.47	2.39	2.22	2.26	2.08	2.18	2.45	2.59	2.64	2.69	2.40

Table Showing the Fluctuation in Lake Huron.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1878.....	2.79	2.96	2.79	2.86	2.46	2.29	2.25	2.35	2.64	2.63	2.82	3.02	2.66
1879.....	3.32	3.56	3.60	3.57	3.44	3.30	3.26	3.39	3.47	3.71	3.83	3.85	3.53
1880.....	3.80	3.86	3.87	3.86	3.46	2.97	2.66	2.77	2.88	3.24	3.36	3.56	3.36
1881.....	3.69	3.30	3.29	3.27	2.95	2.78	2.63	2.80	2.96	2.71	2.58	2.75	2.98
1882.....	2.90	3.13	2.99	2.77	2.60	2.37	2.23	2.17	2.29	2.52	2.77	2.92	2.64
1883.....	3.12	3.17	3.13	3.12	2.55	2.13	1.65	1.45	1.77	2.10	1.99	2.10	2.36
1884.....	2.29	2.44	2.40	2.09	1.87	1.81	1.73	1.85	2.20	2.04	2.39	2.65	2.15
1885.....	2.38	2.47	2.47	2.36	1.96	1.67	1.61	1.46	1.56	1.79	1.98	2.18	1.99
1886.....	2.18	2.11	1.92	1.63	1.30	1.21	1.37	1.52	1.70	1.83	2.10	2.42	1.77
1887.....	2.59	2.40	2.19	2.28	2.08	1.96	1.88	2.09	2.44	2.66	3.11	3.40	2.42
1888.....	3.51	3.60	3.43	3.29	2.85	2.55	2.52	2.48	2.78	3.07	3.25	3.46	3.07
1889.....	3.60	3.68	3.78	3.77	3.63	3.30	3.04	3.10	3.27	3.64	3.98	4.14	3.57
1890.....	4.07	4.19	4.21	4.07	3.76	3.33	3.14	3.14	3.41	3.62	3.82	4.12	3.74
1891.....	4.32	4.43	4.46	4.13	3.89	3.94	3.91	4.01	4.21	4.57	4.88	4.94	4.31
1892.....	4.92	4.98	4.92	4.84	4.71	4.18	3.89	3.81	3.98	4.19	4.52	4.76	4.48
1893.....	5.01	5.06	4.98	4.60	3.97	3.22	3.50	3.64	3.93	4.14	4.37	4.57	4.25
1894.....	4.62	4.61	4.46	4.23	3.83	3.53	3.38	3.65	3.84	4.08	4.27	4.57	4.09
1895.....	4.82	4.94	4.93	4.83	4.66	4.59	4.62	4.71	4.84	5.13	5.52	5.76	4.95
1896.....	5.69	5.57	5.67	5.64	5.24	4.87	4.81	4.77	4.95	5.15	5.29	5.41	5.25
1897.....	5.33	5.42	5.28	4.94	4.37	4.15	3.95	3.94	4.20	4.55	4.67	4.97	4.65
1898.....	5.12	5.06	4.83	4.34	4.22	4.06	3.96	4.07	4.26	4.57	4.65	4.84	4.50
1899.....	5.10	5.24	5.09	4.92	4.38	3.99	3.70	3.79	3.99	4.40	4.54	4.73	4.49
1900.....	4.96	4.95	4.92	4.80	4.65	4.48	4.23	4.14	4.06	4.12	4.12	4.32	4.48
1901.....	4.56	4.70	4.71	4.24	4.03	3.93	3.75	3.68	3.96	4.17	4.41	4.74	4.24
1902.....	4.83	5.03	5.12	4.89	4.68	4.29	4.06	4.02	4.27	4.58	4.66	4.89	4.61
1903.....	5.11	5.07	4.93	4.58	4.46	4.29	4.10	4.12	4.05	4.02	4.44	4.73	4.49
1904.....	4.78	4.78	4.61	3.06	3.74	3.27	3.14	3.16	3.33	3.43	3.74	4.19	3.77
Mean.... 1860-1903	4.27	4.31	4.24	4.02	3.71	3.47	3.31	3.34	3.50	3.72	3.91	4.14	3.86

Remarks. The elevation for February, 1819, is shown from the Michigan Geological report; for June, 1819, 1828, 1830, 1836, 1837; the years 1839, 1840, and January, 1841, from an article by Chas. Whittlesey, Michigan Geological Report for 1839, and table by Mr. A. W. Higgins. During the years 1860-1864 inclusive, the readings are from the Point Aux Barques, Michigan, gage; from 1865-1870 at Milwaukee, Wisconsin; from 1871-1874, inclusive, at Port Austin, Michigan; from 1875-1903 at the Harbor Beach gage. The interpolated monthly means are indicated by parentheses, and are found for any year by taking the corresponding monthly means at Wisconsin and correcting the same by the average difference between the observed monthly means at Point Aux Barques or Port Austin for that year and the corresponding observed monthly means at Milwaukee, Wisconsin. The readings given above are below the high water of 1838 or the Lake Survey plane of reference. The elevation equal 584.34 feet above sea level. As we have already observed a more accurate determination of this high water mark of 1838 is 584.69 feet A. T. The Sanitary canal at Chicago opened 17th January, 1900. Average discharge January, 1901, 250,000 cubic feet per minute.

During dredging operations of the U. S. Engineers at the mouth of the Saginaw river, the following record of gage readings were taken by the inspectors.

Saginaw River, Michigan. Record of gage readings during dredging operations of the U. S. Engineers.

Years.	Months.	Dates.	Monthly means.	Elevation of mean water level for the month.
1884	October	15–31	*1.63	581.88
1884	November	1–25	*1.74	581.99
1885	May	1–31	*2.26	582.51
1885	June	1–30	*2.51	582.76
1885	July	1–31	*2–51	582.76
1885	August	1–31	*2.68	582.93
1887	August	1–28	*2.21	582.46
1887	September	1–30	*1.77	582.02
1889	May	17–31	*1.10	582.35
1889	June	1–30	*0.99	581.24
1889	July	1–31	*0.99	581.24
1889	August	1–9	*0.97	581.22
1891	May	15–30	*0.21	580.46
1891	June	1–30	*0.26	580.51
1891	July	1–31	*0.15	580.40
1891	August	1–31	*0.01	580.26
1891	September	1–30	–0.23	580.02
1891	October	1–31	–0.57	579.68
1891	November	1–20	–0.86	579.39
1892	May	6–31	–0.52	579.73
1892	June	1–30	–0.08	580.17
1892	July	1–21	*0.03	580.28
1892	October	3–31	–0.38	580.63
1892	November	1–23	–0.48	579.77
1895	May	6–31	–0.54	579.71
1895	June	1–28	–0.54	579.71
1895	July	5–29	–0.56	579.69
1895	August	1–30	–0.71	579.54
1895	September	3–28	–0.93	579.32
1895	October	1–31	–1.31	578.94
1895	November	1–29	–1.51	578.74
1896	April	21–30	–1.54	578.71
1896	May	1–28	–1.17	579.08
1896	June	1–30	–0.75	579.50
1896	July	1–11	–0.68	579.57
1899	September	11–30	*0.07	580.32
1899	October	2–31	–0.36	579.89
1899	November	1–30	–0.39	579.86
1900	May	15–31	–0.48	579.77
1900	June	1–30	–0.46	579.79
1900	July	1–24	–0.37	579.88

REMARKS.

The monthly means are computed from tri-daily readings taken by the inspectors while the dredging operations were in progress at the mouth of the Saginaw river.

The gage is located on the channel face of the front L. H. crib of the Saginaw River range, and its zero is 8.525 feet below the top of this crib.

The elevation of the zero of this gage, from comparison of 29 monthly means with corresponding ones at Sand Beach Harbor, Lake Huron, is 580.25 feet above mean tide at New York.

From comparison of May, June and July, 1889, September, 1887, and May, June, July and August, 1885, with the Milwaukee gage, we find the elevation to be (584.38-4.13625)=580.24 A. T.

7. *Explanation of Contour Map.*

In the descriptive portion of the topography which pertains to this chapter, the elevations are given above tide. By this is meant the elevation above the mean tidal height at Governor's Island in New York bay. This is the zero or base which has been adopted by the U. S. Government, and all topographic elevations are stated as so many feet or fractional parts of a foot above this datum or zero. In the contour lines which are represented on the map forming part of this report, each line is intended to represent the same constant elevation above sea level, or above tide as it is usually stated. This is generally abbreviated A. T. In this connection, as to the proper significance of contours, we may quote from the Huron county report.[1] "As we have said, in 1896, Lake Huron had been retreating. Imagine the process suddenly reversed, and the lake raised 10 feet and the new shore line marked upon the map. Suppose the lake raised 10 feet more, and the resulting shore line marked upon the map of the county. Such lines would be called contour lines, and all points of a given contour line are obviously at the same level above the lake." In the map presented in this report the contour lines are represented at intervals of approximately five feet of vertical elevation. In the lowest contour line adjacent to Saginaw bay, it will be observed that the line is marked 585. This means that if Saginaw bay were to rise 5.4 feet from its elevation of 579.61 A. T. in December, 1903, that the shore line of the lake would wash the plain and sand ridges and form inlets up the valleys as indicated by this 585 foot line. The same would be true of each successive line of greater elevation. In the different intervals, islands would occasionally appear. These imaginary islands are represented by contour lines which entirely enclose a certain amount of land. Such an area will be observed in the southwestern part of Williams township, where the 650 foot contour line encloses a sand ridge. It will be readily observed that there is a great advantage in having a common base as a reference plane from which to estimate all points of elevation, and in this report it may be understood that the mean tidal elevation of New York bay furnishes such a base. In the chapter on coal the same base was used to obtain the elevation of the different coal seams, from which the correlations were worked out. The contours are based on 121 drain lines, 41 lines of roads and water works lines of levels, and all the railroad profiles in the county, with the exception of two lines extending north and south of Mt. Forest. This information was supplemented by a large number of aneroid elevations which were checked from base lines and barograph sheets. With the road and drain levels, the elevation of all the stations of each line were obtained above sea level, and every five feet of elevation plotted as accurately as possible on the contour map.

In the remarks made above we only had reference to vertical elevations. It is also obvious that in order to produce an accurate contour map, the horizontal position of topographic features must be taken into account. In Bay county the old beach lines of the former lake system, intermittent and constant water courses, together with two or three slightly developed morainal systems, are the only pronounced surface features which should be taken into account, excepting certain swamp areas, which were more or less accurately delineated by the Linear Survey. The beach lines of any importance were meandered, the compass lines being checked up from section and quarter corners. The course of the Saginaw river was meandered by the Linear Survey, and at a later date the lower reaches were accurately located by the U. S. Lake Survey. The course of the Kawkawlin river and its two forks was only obtained by the Linear Survey at the intersection of the section lines. In the interior of sections we have obtained a number of checks on this river from drain and beach meanders. The location of most of the intermittent streams in the lower half of the county is from drain meanders. Farther north, Mr. Shaw and I obtained a large amount of additional information in the course of the township surveys. Aside from the

[1] Michigan Geological Survey, Volume VII, part 2, p. 42.

topographic features, the greater part of Bay county may be said to be a plain gently sloping towards Saginaw bay and Saginaw river. An exception to this is found in the moraine, which trends through the western part of Gibson township, which produces a fairly well marked line of range hills in the northwestern part of the township. These hills face the west, the descent on the side away from the ice being much more pronounced than where the material was deposited underneath and immediately in front of the retreating glacier. Taking into account all the factors which enter into the preparation of a contour map, and the comparative simplicity of the topography, it is believed that the map here presented is sufficiently accurate and detailed to serve the purposes of drainage, engineering, and general scientific research.

The streams of Bay county are either estuaries of the bay, or intermittent during a portion of the year. Such an estuary stream is the Saginaw river, which occasionally flows north or south according to the direction and velocity of the wind in altering the elevation of its outlet into the bay. It was noted in the chapter on coal that the middle and perhaps upper reaches of the water course in Bay county, occupied a line of reversed preglacial drainage. There seems to have been considerable uniformity in the amount of drift deposited in the lower portion of Bay county, which may account for the depression in which the river is located here. Whether the Saginaw has at one time deposited a delta at its mouth is not certain. The topography of the bay shore east of the outlet, and as far as the inlet on the range line 5 and 6 E., rather indicates such a lateral delta. In this supposition the inlet above mentioned would be the former outlet of the river. Mr. John H. Blomshield prepared in 1894, a map showing the original meander line and the present course of the river. This would indicate that the river has cut into its east or right bank since the Linear Survey. The general swing of the river east northeast, below its outlet, would favor such a modification.

8. *Kawkawlin River and the South Fork.*

In the present stage of low water elevation, the Kawkawlin river is an estuary of the bay above Henry street. At Kawkawlin village Mr. Blomshield made the elevation of the water surface 581.15 A. T., at the bridge in the west part of town. At the outlet of Culver creek in section 16 of Monitor township, the elevation of the lower fork has increased to 584.5 feet A. T. On the township line between Williams and Monitor, the elevation of two drain lines which empty near each other there is 596 feet A. T. It will be observed that the fall from the town line to the mouth of Culver creek is approximately four feet to the mile, and from there only four feet to the outlet of the river a distance twice as great. This fall is where the stream is deflected by the Monitor moraine. The south fork is also characteristic of the river topography of the Saginaw valley, in that it makes a large bend to the south before finding an outlet. In this measure it is to be compared to the Tittabawassee which swings south around a moraine before emptying into the Saginaw. While the moraine which produces the elevation and deflection of this stream in Bay county is not well marked, the result is, as we have seen, the "willowy" drainage characteristic of the river topography in this region. Where the south fork is crossed by the Garfield road in Beaver township, at the northeast corner of Sec. 27, T. 15 N., R. 3 E,. the elevation is 604.65 feet A. T. North of Duel P. O., and on the east line of section 7 the stream is 635 feet A. T. The stream valley here is in places quite shallow, the bed in some places changing its channel from season to season. North and south of the outlet of Skelton creek, in Williams township, the stream course for over a mile is north and south. This is probably due to the location of the moraine in Monitor township to the eastward. There are indications that this stream existed contemporaneously with the Pleistocene lakes, the stream advancing as the lake receded, *pari passu*. At the time that the Algonquin beach was being formed, this fork probably emptied into lake Algonquin near the present township line of Monitor and Williams. On the south side of the stream course there, the drainage has no outlet directly into the river. I have taken this dam to be an old flood plain. The elevation there is nearly 600 feet A. T.

The Lower fork of the Kawkawlin, in common with the Tittabawassee, receives a much larger number of tributaries from the south and west than from the north. In fact there is scarcely any drainage stream which comes in from the north worthy of mention. From the south there are six water courses flowing northeast and east which serve as valuable drainage outlets in Monitor, Williams and Beaver townships. Going up stream these are known as Culver, Hopler, Perry, Skelton, Willard and Davis creeks. This drainage result is probably due to the more even and extended deposition on the back and bottom of the moraine last deserted, which as we have seen in Gibson township, is more abrupt in front. In Williams the crest of this moraine trends northwest, in the southwestern part of the township. Farther south it passes north and east of Freeland in Saginaw county. Mr. F. B. Taylor correlates this moraine with the one we have observed in the western part of Gibson. If this is true it is not very well marked east of Midland or Estey. The crest of this formation is the divide between the Tittabawassee river on the west, and the Kawkawlin and other drainage courses directly tributary to the bay, to the east. The amount of rainfall which goes into the Tittabawassee from Bay county is a negligible quantity.

9. *The North Fork of the Kawkawlin River.*

The north fork of the Kawkawlin passes through Kawkawlin, Beaver and Garfield townships. North of Bedell's corners the water level is 593.3 A. T., on the Garfield road near the northeast corner of section 10 in Beaver, the height has increased to 613.3 feet A. T.; at the north quarter post of section 18 in Garfield, Mr. John H. Blomshield made the elevation 637.74 A. T. It will thus be seen that the project to make a dredge cut out of this stream is scarcely feasible. In the western portion of Garfield township this water course occupies a well marked valley which is much too large for the present stream course. This valley way is probably the result of morainal inequalities of deposition. The antiquity may be inferred from the beach lines which occasionally flank both sides of the stream, being deposited when the lake formerly extended as an inlet up what is now the valley. It has therefore been assumed that the valley was formed previous to its occupancy by this stream, the stream being consequent and not formative. Throughout its course in the northern part of Beaver and the northwestern part of Kawkawlin township, this stream generally occupied a large and relatively deep valley which evidently owes its origin to a different agency than the present stream. Inasmuch as this region was covered with water at the time of the glacial retreat, its origin can scarcely be ascribed to ice drainage. Above its outlet, in the eastern part of Kawkawlin township, the stream has rather a rapid fall to the south, the course of the stream probably being determined by the same low, ill defined moraine, which we had occasion to notice in connection with the south fork in Monitor township.

During the period when lumbering was an important occupation in Bay county, the persons engaged in that occupation, located what are known locally as bayous in this fork of the river, in the eastern and central portion of Kawkawlin township. The O'Neil bayou situated in section 27 is about one-half mile long, and is said to be from 12 to 14 feet deep. At its upper extremity there is a sandbar called Joe Duponts neck on the east and west quarter line of section 27. Next above this is the Silvernail bayou extending from the south 80-rod line of section 22, and up stream for over a quarter of a mile west of the town hall. The depth is not far from eight feet. The Allen bayou, next going up stream, begins 40 rods south of the sawmill in the northwest quarter of section 21, and runs north 100 rods. The depth varies from six to eight feet. The White bayou is in the southeast quarter of section 17. These so-called bayous are not so in the proper sense of the word, being only deep pools of water in the present stream course, and not semi-isolated channels. In the south, bayous are commonly formed by the cutting of ox bows, leaving the stream to pursue, at least for the time being, a more direct course. The notes concerning the Kawkawlin river bayous were given me by several men formerly engaged in lumbering along this fork. They have also come under the observation of G. M. Bradford, a botanical student of Bay county, and J. H. Tryon of the Agricultural College.

10. *Drainage in Northern Bay County.*

The drainage in the remaining portion of Bay county is of the simplest and most natural character, the stream courses following slight surface inequalities due to inequalities of morainal formation along a smooth tilted plain. Occasionally these swales are flanked by low sandy elevations, which occasionally rise into beach lines. The principal drainage courses such as Michie creek, Chute creek, Pinconning creek, White Feather creek, and the different feeders of the Saganing and Pine river in Mt. Forest and Gibson townships, extend over three-quarters of the way across Bay county east and west. They pursue independent and nearly parallel lines of drainage. In future drainage operations they could very well be cleaned out, straightened and deepened so as to serve in reclaiming considerable areas of fertile land. If they are made to serve as drain trunk lines the size should considerably exceed that of drains which only tap relatively limited areas.

11. *Bay County Drains.*

With the exception of drains actually meandered or levelled, the areas tributary to the different drains have in general not been given. Such areas can be determined from the contour map. In all other cases where we were able to obtain the location and elevation of drain courses, the area tributary to that drain will be found printed with the location in the latter portion of this chapter. These drains have been arranged in alphabetic order and numbered from 1 to 121, there being that many lines of levels. On the contour map these numbers have been used instead of the names of the different drains. In many cases, as in the levels of Hopler and Skelton creeks in Williams township, the drains have not been dug. The levels, however, even if not directly available, will serve to show the utility of intermittent water courses, and other lines, for drainage purposes. With the numerous other lines of levels the information can be probably used in cleaning out, the depth being made the same as in the original survey, if it is not found advisable to go deeper. The elevations of all drain lines have been obtained above sea level (A. T.), either from the elevation of Saginaw bay, from road and railroad profiles, or lines of levels especially run by J. H. Blomshield for this purpose. By having each line conform to a definite base, such work is rendered more systematic, and the work of determining drainage areas made more equitable. In future surveys it will probably be found useful to connect lines of levels with the levels and elevations given in this report.

For additional information concerning drain construction and engineering, the reader is referred to a publication entitled "The Drainage of Fens and Low Lands," by W. H. Wheeler.

12. *Tables of Elevations.*

Primarily all of these elevations are based on the table of fluctuations of Lake Huron. The elevations here presented were obtained from railroad profiles and from the County Commission. In all cases the elevation is stated above tide, together with the local elevation from which this was generally determined.

Michigan Central R. R. Jackson, Lansing & Saginaw Division.

	A. T.
Saginaw-Bay county line	584
Brooks	587
Center street, West Bay City	598
West Bay City	587
Henry street, West Bay City	597
Kawkawlin	599
Linwood	589
State Road (Michie P. O.)	602
Pinconning	600
White Feather	604
Bay—Arenac county line	618

Michigan Central R. R. Detroit & Bay City Division.

Reese	628
Arn	597
Quanicassee State Drain	595.34
Mungers	596
Bay City	592

Michigan Central R. R. Midland Division.

Monitor station	600
Auburn	617
Fisherville	639
Colden on Bay—Midland county line	659

Michigan Central R. R. Saginaw Bay & Northwestern Division.

Pinconning, J., L. & S. crossing	594
Beardsleys	618
Woodville	627
Nine Mile	656
Mt. Forest	690

Elevations of post offices in Bay county determined with spirit level.

Bedell, Michigan Geological Survey	599
Bently, Michigan Geological Survey	737
Crump, Bay County Stone Roads Commission	633
Cummings, Bay County Drain Commission	620
Garfield, P. O., Michigan Geological Survey	626
North Williams, Bay County Stone Roads Commission	614

In the railroad elevations given above the point taken is the base of the rail in front of the depot, excepting for the Midland division, where the elevation is the surface of the ground at the depot or siding.

13. *Bay County Drains and Drainage Areas.*[1]

1. Alarie drain. Outlet Saginaw Bay on the N. line of Sec. 18, T. 16 N., R. 5 E Drainage area, the N. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, the N. ½ of the N. E. ¼ of the N. W. ¼ and the N. ½ of the N. W. ¼ of the N. W. ¼, Sec. 13, T. 16 N., R. 4 E. The N. ½ of the N. ½ of the N. E. ¼ of Sec. 14, T. 16 N., R. 4 E. and the S. ½ of the S. ½ of the S. E. ¼, Sec. 11, T. 16 N., R. 4 E. Total length 494 rods. Amount of fall 13 feet.

2. Allison drain. Outlet into the Russell drain at the N. E. corner of Sec. 15, T. 13 N., R. 6 E. Drainage area, the E. ½ of the E. ½ of Sec. 15, and the W. ½ of the W. ½ of Sec. 14, T. 13 N., R. 6 E. Length one mile.

3. Aspin drain. Outlet Hopler creek, in the S. W. ¼ of the N. W. ¼, of Sec. 16, T. 14 N., R. 3 E. Drainage area, E. ½ of S. E. ¼ of Sec. 17 and E. ½ of the N. E. ¼, Sec. 20, T. 14 N., R. 3 E.

4. Bancle drain Outlet of drain Saginaw Bay, on the N. line of Sec. 12, Kawkawlin. township, T. 15 N., R. 4 E. Drainage area, the south ½ of the S. ½ of Sec. 1 (fractional), area 46 acres, and the N. ½ of the N. fractional half of Sec, 12, T. 15 N., R. 4 E., the N. E. ¼ of Sec. 11, and the S. ½ of the S. E. ¼ of Sec. 2, T. 15 N., R. 4 E.

5. Bangor and Monitor State drain. Outlet of drain Kawkawlin river near the W. ¼ post of Sec. 1, T. 14 N., R. 3 E. Drainage area N. W. ¼ of the S. W. ¼ of Sec. 1, and the N. E. ¼ of the S. W. ¼, Sec. 1, the S. E. ¼ of the S. W. ¼ of Sec. 1, T. 14 N., R. 4 E.; also in Sec. 12, T. 14 N., R. 4 E., the N. E. ¼ of the N. W. ¼ and the N. W. ¼ of the N. E. ¼, the S. E. ¼ of the N. W. ¼, the S. ½ of the N. E. ¼, and the N. ½ of the S. E. ¼, Sec. 12, T. 14 N., R. 4 E. In Bangor township, T. 14 N., R. 5 E., the S. ½ of the N. W. ¼ and the N. ½ of the S. W. ¼, Sec. 7, also the S. ½ of the S. W. ¼ and the S. ½ of the S. E. ¼ of Sec. 7. In Sec. 18, the E. ½, of the N. W. ¼, and the N. E. ¼ of Sec. 18, also the S. E. ¼ of Sec. 18, and the E. ½ of the S. W. ¼ of Sec. 18, T. 14 N., R. 5 E. In Sec. 19 the N. W. ¼ of the N. E. ¼ and the N. E. ¼ of the N. W. ¼.

6. Baxman drain. Outlet of drain, into the Squaconning creek, on the W. line of Sec. 6, T. 13 N., R. 5 E. Drainage area in Sec. 24, Monitor township, T. 14 N., R. 4 E., the E. ½ of the S. E. ¼. In Sec. 19, T. 14 N., R. 5 E., the W. ½ of the S. W. ¼. In Sec. 25, T. 14 N., R. 4 E., the E. ¼ of the N. E. ¼, and the S. W. ¼ of the N. E. ¼, also the S. E. ¼ of Sec. 25, T. 14 N., R. 4 E. In Sec. 30, T. 14 N., R. 5 E., the W. ½ of the N. W. ¼ and the W. ½ of the S. W. ¼. In Sec. 36, E. ½ of the E. ½, T. 14 N., R. 4 E. and the W. ½ of the W. ½ of Sec. 31, T. 14 N., R. 5 E. In Sec. 1, Frankenlust township, T. 13 N., R. 4 E., the N. E. ¼ of the N. E. ¼ of the N. E. ¼ and in Sec. 6, Frankenlust township, T. 13 N., R. 5 E., the N. W. ¼ of the N. W. ¼ of Sec. 6.

7. Beard drain. Outlet into the Quanicassee and Cheboyganing State drain on the E. and W. ¼ line of Sec. 23 and about 80 rods west of the center of the Sec. This drain

[1] Elevations and locations of the different Bay County drains on file in the office of the State Geologist and the Bay County Drain Commissioner.

is entirely in T. 13 N., R. 6 E. Drainage area, the W. ½ of the S. W. ¼, of the N. W. ¼ of Sec. 23, and in Sec. 23, the N. W. ¼ of the N. W. ¼ of the S. W. ¼. In Sec. 22, the S. ½ of the N. E. ¼ and the N. ½ of the N. E. ¼ of the S. E. ¼, also the N. W. ¼ of the S. E. ¼, Sec. 22, the S. ½ of the N. W. ¼ and the N. ½ of the S. W. ¼, Sec. 22. The S. ½ of the N. E. ¼ and the N. ½ of the S. E. ¼ Sec. 21. The S. E. ¼ of the N. W. ¼ and the N. E. ¼ of the S. W. ¼, the E. ½ of the S. W. ¼ of the N. W. ¼, the E ½ of the N. W. ¼ of the S. W. ¼, the N. W. ¼ of the N. W. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼ of the N. W. ¼, all in Sec. 21.

8. Behmlander drain. The north outlet of this drain is into the Kawkawlin river, in the S. E. ¼ of Sec. 2, Monitor township, T. 14 N., R. 4 E. The south outlet is in Sec.1, Frankenlust township, T. 13 N., R. 4 E., where it empties into an estuary of Squaconning creek. Drainage area in Sec. 1, T. 13 N., R. 4 E., is approximately the N. E. ¼ of the N. W. ¼. The following drainage areas is included in T. 14 N., R. 4 E. In Sec. 36 the S. W. ¼, in Sec. 35, the E. ½ of the S. E. ¼. The N. E. ¼ of Sec. 35, and the W. ½ of the N. W. ¼ of Sec. 36, also in Sec. 35, the N. ½ of the N. W. ¼ and the S. ½ of the S. W. ¼ of Sec. 26. The drainage here is cut up by an old beach line. In Sec. 34, the N. E. ¼ of the N. E. ¼. In Sec. 27, the E. ½, in Sec. 26, the W. ½ of the S. W. ¼ and the W. ½ of the N. W. ¼, in Sec. 22, the E. ½ of the S. E. ¼ and the W. ½ of the S. W. ¼ of Sec. 23, also the E. ½ of the N. E. ¼ of Sec. 22 and the W. ½ of the N. W. ¼ of Sec. 23, in Sec. 15, the S. E. ¼ of the S. E. ¼, in Sec. 14, the W. ½, and the N. W. ¼ of the N. E. ¼, in Sec. 11, the S. W. ¼, and the E. ½ of the S. E ¼ of Sec. 10, also in Sec. 11, the N. W. ¼ and the N. W. ¼ of the N. E ¼ of the same section, also the S. ½ of that part of Sec. 2, of the S. E. ¼ which lies south of the Kawkawlin river. Levels by J. Madison Johnston.

9 Bennett drain. This drain empties into the Bublitz drain at the S. E. cor. of Sec. 14, T. 13 N., R. 6 E. In Sec. 23, T. 13 N., R. 3 E., the drainage area is , E. ½ of the N. E. ¼, and in Sec. 24, same township and range, the W. ½ of the N. W. ¼, the E ½ of the S. E. ¼ of Sec. 23, and the N. ½ of the S. W. ¼ of Sec. 24, the S. W. ¼ of the S. W. ¼, also in Sec. 24.

10. Betzold drain. The outlet of this drain is in a swale in the N. W. ¼ of the N. W. ¼ of Sec. 36, Beaver township, T. 15 N., R. 3 E. The drainage area is the W. ½ of the S. E. ¼ of Sec. 23, and the E. ½ of the S. W. ¼, of Sec. 23, the N. ½ of the N. E. ¼, and the S. ½ of the N. E. ¼ of Sec. 26, and the N. ½ of the S. E. ¼ and the S. E. ¼ of the S. E. ¼ of Sec. 26. Also in Sec. 25, the S. W. ¼ of the S. W. ¼. In Sec. 35, the N. E. ¼ of the N. E. ¼, and in Sec. 36, the N. W. ¼ of the N. W. ¼. This drain is all in T. 15 N., R. 3 E.

11. Birch Road drain. Outlet of drain is into the Young drain at the N. E. corner of Sec. 36, Portsmouth township, T. 14 N., R. 5 E. The drainage area in Sec. 36, is the E. ½ of the E. ½ while in Sec. 31, T. 14 N., R. 6 E., it is the west half of the N. W. ¼, also in Sec. 31, the W. fractional ½ of the S. W. ¼. In Sec. 1, T. 13 N., R. 5 E., there is the E. ½ of the N. E. ¼ of the N. E. ¼ and the S. E. ¼ of the N. E. ¼. In Sec. 6, T. 13 N., R. 6 E., there is the W. ½ of the W. ½ of the N. W. ¼ and the E. ½ of the S. W. ¼ of the N. W. ¼, Sec. 6, also in the same section, the N. W. ¼ of the S. W. ¼. In Sec. 1, T. 13 N., R. 5 E., the N. E. ¼ of the S. E. ¼.

11A. Bowkowtonden drain. Outlet of drain in the Kawkawlin river on the north line of Sec. 2, Monitor township, T. 14 N., R. 4 E. The following drainage areas are included in the above township and range. In the Bowkowtonden reserve, the N. ½ of the N. ½ of that part lying north of the quarter line road of Secs. 3 and 2. Also in the N. ½ of the N. W. ¼, of Sec. 3. In Sec. 4, the N. ½ of the N. E. ¼ and the N. ½ of the N. W. ¼. In Sec. 5, the N. ½ of the N. ½, in sec. 6, the N. ½ of the N. ½. In Kawkawlin township, T. 15 N., R. 4 E., are the following drainage areas. In Sec. 35, that part of the S. W. ¼ lying west of the river, and the south 80 rod line. In Sec. 34, the S. ½ of the S. ½, in Sec. 33, the S. ½ of the S. ½, and the S. ½ of the S. ½ of Sec. 32, and the S. ½ of the S. ½ of Sec. 31.

12. Bradford Creek drain. The outlet of this drain is into the south fork of the Kawkawlin river, just west of the Sec. line between 16 and 17, T. 14 N., R. 4 E. The following drainage areas are in the same township and range, the S. E. ¼ of Sec. 17, the N. W. ¼ of the N. E. ¼ of Sec. 20, the S. E. ¼ of the S. W. ¼ of Sec. 17, the N. W. ¼ of Sec. 20, the E. ½ of the N. E. ¼ of Sec. 19, the N. E. ¼ of the S. E. ¼ of Sec. 19, the S. W. ¼ of the N. E. ¼ of Sec. 19, the W. ½ of the S. E. ¼, Sec. 19, the E. ½ of the S. W. ¼ of 19, the N. ½ of the N. W. ¼ of Sec. 30. In Williams township, T. 14 N., R. 3 E., the following lands are drained, the N. E. ¼ of Sec. 25, the N. W. ¼ of the S. E. ¼, Sec. 25, the E. ½ of the S. W. ¼ of Sec. 25, the S. W. ¼ of the S. W. ¼ of Sec. 25. In Sec. 26, the S. ½ of the S. ½ of the S. E. ¼, in Sec. 35, the N. E. ¼ of the N. E. ¼, the W. ½ of the N. E. ¼, the N. W. ¼ of Sec. 35. In Sec. 34, the N. E. ¼ and the N. ½ of the S. E. ¼, the S. W. ¼ of Sec. 34, and the S. E. ¼ of the N. W. ¼ of Sec. 34. In Sec. 33, the N. ½ of the S. E. ¼ and

the S. ½ of the N. E. ¼, also in the same section, the N. E. ¼ of the S. W. ¼ and the S. ½ of the S. E. ¼ of the N. W. ¼.

13. Brown drain. The outlet of this drain is into the Cheboyganing river, on the line between sections 22 and 27, Buena Vista township, Saginaw county, T. 13 N., R. 5 E. The drainage area in Merritt township, Bay county, T. 13 N., R. 6 E., is as follows: Sec 30, N. W. ¼, the W. ½ of the N. E. ¼, the N. E. ¼ of the N. E. ¼; Sec. 19, the S. W. ¼, the W. ½ of the S. E. ¼, and the S. E. ¼ of the S. E. ¼.

14. Bublitz drain. The outlet of this drain is into the Quanicassee and Cheboyganing State drain, between sections 13 and 14, Merritt township, T. 13 N., R. 6 E. The drainage area is as follows: In Sec. 13, same township and range, the S. ½ of the N. W. ¼ of the S. W. ¼, the N. ½ of the S. W. ¼, of the S. W. ¼, the S. W. ¼ of the S. W. ¼ of the S. W. ¼; in Sec. 24, the W. ½ of the N. W. ¼ and the E. ½ of the N. E. ¼ in Sec. 23.

15. Budd drain. The outlet of this drain is into Saginaw Bay on the north line of Sec. 6, Pinconning township, T. 17 N., R. 5 E. The drainage areas in the same section are as follows: The north fractional half of the N. fractional half; in Sec. 1, T. 17 N., R. 4 E., the N. fractional half of the N. E. ¼, also the N. ½ of the N. E. ¼ of the N. W. ¼, also in the same section, the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 2. the N. fractional half of the N. E. ¼, also the N. fractional ½ of the N. ½ of the N. W. fractional quarter; in Sec. 3, the N. fractional half of the N. ½.

16. Carney Road drain. The outlet of this drain is the end of the Saginaw river in the S. E. ¼ of Sec. 15 T. 14 N., R. 5 E. The drainage area is as follows: The S. E. fractional ¼ of Sec. 15, the E. ½ of Sec. 22, the E. ½ of Sec. 27, and the S. E. ¼ of the S. W. ¼ of Sec. 27, T. 14 N., R. 5 E.

17. Center Avenue Dredge Cut. The outlet of this drain is into the Saginaw Bay. The drainage area as far as I have been able to obtain the elevations of the same is as follows: In Sec. 27, Hampton township, T. 14 N., R. 6 E., are as follows, the N. W.. ¼; in Sec. 28, same township and range, the N. ½; in Sec. 21, the S. ½; in Sec. 29, the N. ½; in Sec. 20, the S. W. ¼, the W. ½ of the S. E. ¼, and the S. E. ¼ of the S. E. ¼. The location of the outlet is in Tuscola county, T. 14 N., R. 7 E.

18. Chip Road drain. The outlet of this drain is into the north fork of the Kawkawlin river, Sec. 2, T. 14 N., R. 4 E. The drainage area is as follows: In the Bowkowtonden reserve, Sec. 2, the S. ½ of the S. ½, and the N. ½ of the N. ½, in Sec. 3, same township and range, the S. ½ of the S. ½, and the N. ½ of the N. ½,

19. Chute Creek drain. The outlet of this drain is into Saginaw Bay, on the E. and W. ¼ line of Sec. 6, T. 16 N., R. 5 E. The drainage area in the same section is the S. W. fractional quarter of the N. W. fractional ¼; in Sec. 1, T. 16 N., R. 4 E., there is the N. E. ¼ and the N. ½ of the S. E. ¼, the N. W. ¼ and the N. ½ of the S. W. ¼; in Sec. 2, the N. E. ¼, in Sec. 35, Pinconning township, T. 17 N., R. 4 E., there is the S. W. ¼ of the S. E. ¼, also the S. W. ¼. In Sec. 34, same township and range, there is the S. E. ¼; in Sec. 3, T. 16 N., R. 4 E., there is the N. ½ of the N. E. ¼, the N. W. ¼; in Sec. 4, the N. E. ¼, and the S. E. ¼, also the N. ½ of the S. W. ¼ and the S. ½ of the S. ½ of the N. W. ¼; Sec. 5, the S. ½, also the S. ½ of the N. W. ¼; in Sec. 6, the N. ½ of the S. ½, and the S. W. ¼ of the N. W. ¼, T. 16 N., R. 4 E.

20. Coggin's drain. The outlet of this drain is into the Chute Creek drain in the N. E. ¼ of the S. W. ¼ of Sec. 4, Fraser township, T. 16 N., R. 4 E. The drainage area is as follows: The S. E. ¼ and the S. W. ¼ of the S. W. ¼; in Sec. 9, the N. W. ¼ of the N. W. ¼; in Sec. 8, the N. E. ¼, the N. E. ¼ of the N. W. ¼, the S. ½ of the N. W. ¼ and the N. ½ of the S. W. ¼. All in T. 16 N., R. 4 E.

21. Conklin drain. The outlet of this drain is into Saginaw Bay in the N. W. fractional quarter of the S. W. fractional quarter, of Sec. 24, Fraser township, T. 16 N., R. 4 E. Drainage area, the N. W. ¼ of the N. W. fractional quarter of the S. W. fractional quarter of Sec. 24, also the S. W. ¼ of the W. ¼ of the same section. In Sec. 23, the E. ½ of the N. E. ¼, and the N. W. ¼ of the N. E. ¼, the N. W. ¼ of the same section; in Sec. 14, the S. ½.

22. Corbin drain. The outlet of this drain is into the Kawkawlin river on the line between Secs. 32 and 33, Bangor township, T. 15 N., R. 5 E., on the south bank of the river. Drainage area, in Sec. 5, T. 14 N., R. 5 E., is the N. E. fractional ¼ of the N. E. ¼, and the S. E. ¼ of the N. E. ¼, the E. ½ of the S. E. ¼; in Sec. 4, the W. ½ of the N. W. ¼ and the W. ½ of the S. W. ¼; in Sec. 8, the E. ½ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, and the S. E. ¼ of the S. E. ¼; in Sec. 9, the W. ½ of the W. ½.

23. County line drain. The outlet of this drain is into the Quanicassee river in the S. W. ¼ of the S. E. ¼ of Sec. 1, Merritt township, T. 13 N., R. 6 E. The drainage area beginning at the outlet is as follows, in Bay county: The S. E. ¼ of the S. E. ¼, the E. ½ of the E. ½, in Sec. 13; in Sec. 24, the E. ½ of the N. E. ¼, and the N. E. ¼ of the S. E. ¼; and the E. ½ of the S. E. ½ of the S. E. ¼ in Sec. 25, the S. E. ¼ of the N. E. ¼, the E. ½ of the S. E. ¼. This drain is not constructed.

24. Culver Creek drain. The outlet of this drain is into the south fork of the Kawkawlin river in the S. E. ¼ of the N. E. ¼ of Sec. 16, Monitor township, T. 14 N., R. 4 E. Drainage area includes the S. W. ¼ of the S. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the S. W. ¼, in Sec. 16; in Sec. 21, the N. ½ of the N. W. ¼ and the W. ½ of the S. W. ¼ of the N. W. ¼; in Sec. 20, the S. E. ¼ of the N. E. ¼, the S. ½ of the S. W. ¼ of the N. E. ¼, all the S. E. ¼, the S. E. ¼ of the S. W. ¼; in Sec. 29, the N. W. ¼, excepting the N. W. ¼ of the N. W. ¼. In Sec. 30, the N. E. ¼ and the S. E. ¼, also the S. W. ¼; in Sec. 31, the N. ½ of the N. W. ¼.

25. DeCorte drain. The outlet of this drain is into the Young drain at the N. ¼ post of Sec. 32, Portsmouth township, T. 14 N., R. 6 E. Drainage area is as follows: The S. ½ of the N. W. ¼, of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, and the N. ½ of the S. W. ¼ of the S. E. ¼, also in the same section 32, the N. ½ of the S. E. ¼ of the S. W. ¼, the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the N. W. ¼, and the S. ½ of the N. E. ¼ of the N. W. ¼.

26. Dell Creek drain. The outlet of the drain is into the south fork of the Kawkawlin river, on the S. bank where it is intersected by the N. and S. ¼ line of Sec. 12, Williams township, T. 14 N., R. 3 E. The drainage area is as follows: The S. ½ of the S. E. ¼ of the N. W. ¼, Sec. 12, the N. W. ¼ of the S. W. ¼, and the S. W. ¼ of the S. W. ¼ of the same section 12; in Sec. 11, the S. ½ of the S. E. ¼ of the S. E. ¼; in section 14, the N. E. ¼ and the S. E. ¼; in section 13, the W. ½ of the W. ½; in Sec. 23, the E. ½; in Sec. 24, the W. ½ of the W. ½; in Sec. 25, the W. ½ of the N. W. ¼, the N. W. ¼ of the S. W. ¼; in Sec. 26, the N. E. ¼ of the S. E. ¼ and the N. E. ¼. This is all in T. 14 N., R. 3 E.

27. Derosia drain. The outlet of this drain is 46 chains north of the S. E. corner of Sec. 18, Monitor township, T. 14 N., R. 4 E., where it empties into a swale, running east northeast, into the south fork of the Kawkawlin river, in Sec. 17, T. 14 N., R. 4 E. Drainage area is the S. E. ¼ of Sec. 18, the N. E. ¼ of Sec. 19, the S. E. ¼ of Sec. 19, the W. ½ of the S. W. ¼, of Sec. 20.

28. Dewey drain. The outlet of this drain is into the north branch of Squaconning creek, between Secs. 33 and 34, Monitor township, T. 14 N., R. 4 E. Drainage area includes the N. E. ¼ of Sec. 33, the W. ½ of the N. W. ¼ of Sec. 34, the E. ½ of the S. E. ¼ of Sec. 28, the W. ½ of the S. W. ¼ of Sec. 27.

29. Dewitt drain. The outlet of this drain is into the Ryon drain on the section line between 22 and 27, Fraser township, T. 16 N., R. 4 E. Drainage area includes the W. ½ of the N. E. ¼ and the E. ½ of the N. W. ¼ of the N. W. ¼ of Sec. 27, the S. ½ of the N. W. ¼, Sec. 27, and the S. W. ¼ of the same section; in section 34, the N. W. ¼ of the N. W. ¼; in Sec. 33, the N. E. ¼ and the N. ½ of the N. W. ¼; in Sec. 28, the S. ½ of the S. E. ¼ and the S. E. ¼ of the S. W. ¼.

30. Dutton drain. This drain empties into the Ryon drain on the line between Secs. 20 and 21, Fraser township, T. 16 N., R. 4 E. Drainage area, in Sec. 20, the E. ½ of the N. E. ¼ and the N. W. ¼ of the N. E. ¼; in Sec. 21, the W. ½ of the N. W. ¼; in Sec. 16, the S. W. ¼ of the S. W. ¼; in Sec. 17, the S. E. ¼ of the S. E. ¼.

31. Eagan drain. The outlet of this drain is into the Monitor drain on the line between Secs. 12 and 13, Monitor township, T. 14 N., R. 4 E. Drainage area, the S. ½ of the S. E. ¼, Sec. 12, and the N. E. ¼ of Sec. 13, T. 14 N., R. 4 E.

32. Edsall drain. The outlet of this drain is into the south fork of the Kawkawlin river, in the N. E. ¼ of the N. W. ¼ of Sec. 10, Monitor township, T. 14 N., R. 4 E. Drainage area, in Sec. 10, is the N. ½ of the N. E. ¼ of the N. W. ¼ and the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 3, the S. ½ of the S. W. ¼; in Sec. 4, the S. ½ of the S. ½; in Sec. 9, the N. ½.

33. Ellison drain. The outlet of this drain is into the Munger drain, at the N. W. corner of Sec. 21, Merritt township, T. 13 N., R. 6 E. The drainage area in Sec. 20 is the S. E. ¼ of the N. E. ¼ and the E. ½ of the N. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼ and the E. ½ of the S. E. ¼; in Sec. 21, the W. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the W. ½ of the S. W. ¼; in Sec. 29, the E. ½ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, the E. ½ of the S. E. ¼ of the S. E. ¼; in Sec. 28, W. ½ of the S. W. ¼, the S. W. ¼ of the N. W. ¼ and the W. ½ of the N. W. ¼, of the N. W. ¼.

34. Flood drain. The outlet of this drain is into the Ryon drain, ½ of a mile west of the N. E. corner of Sec. 30, Fraser township, T. 16 N., R. 4 E. Drainage area includes the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. W. ¼, the N. W. ¼ of the N. W. ¼, the S. ½ of the N. W. ¼, the N. ½ of the S. W. ¼ and the S. W. ¼ of the S. W. ¼, all in Sec. 30, T. 16 N., R. 4 E. Indirectly this drain receives some water coming from the S. ½ of Sec. 25, Garfield township, T. 16 N., R. 3 E.

36. Forster drain. Outlet into the Culver Creek drain, 993 feet west of the line between Secs. 20 and 21, and 406 feet south of the ¼ section line of Sec. 20, Monitor township, T. 14 N., R. 4 E. Drainage area, in Sec. 20, S. E. ¼ of the S. E. ¼; in Sec. 21, the S. W. ¼ of the S. W. ¼; in Sec. 28, the W. ½ of the N. W. ¼ and the N. W. ¼ of the S. W. ¼, and the W. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 29, the E. ½ of the N. E. ¼, and the S. E. ¼ of the S. E. ¼.

38. Garfield drain. The outlet of this drain is into Hopler creek, on the line between Secs. 10 and 11, just south of the ¼ post, Williams township, T. 14 N., R. 3 E. Drainage area in Sec. 10, the S. E. ¼ of the S. E. ¼; in Sec. 11, the W. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 14, the W. ½ of the W. ½ of the S. W. ¼; in section 15, the E. ½; in Sec. 22, the E. ½; in Sec. 23, the W. ½ of the W. ½ of the W. ½; in Sec. 27, the N. E. ¼; in Sec. 26, the W. ½ of the W. ½ of the N. W. ¼.

39. Garvie drain. This drain empties into the north fork of the Kawkawlin river in the S. E. ¼ of the S. E. ¼, of Sec. 22, Kawkawlin township, T. 15 N., R. 4 E. Drainage area: In Sec. 22, is the S. W. ¼ of the S. E. ¼; in Sec. 27, the N. ½ of the N. W. ¼; in Sec. 28, is the N. ½ of the N. E. ¼, in Sec. 21, the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, and the E. ½ of the S. W. ¼ of the S. W. ¼, all in T. 15 N., R. 4 E.

40. Gates drain. This drain empties into the Tromble drain at the S. ¼ post of Sec. 11, Portsmouth township, T. 13 N., R. 5 E. Drainage area in Sec. 11, the E. ½ of the W. ½, the W. ½ of the N. W. ¼, the N. W. ¼ of the S. E. ¼, and the W. ½ of the S. W. ¼ of the S. E. ¼.

41. Geno drain. This drain has its outlet into Saginaw Bay at the S. ¼ post of Sec. 13, Fraser township, T. 16 N., R. 4 E. Drainage area, the S. ½ of the S. W. ¼ of Sec. 13, the N. ½ of the N. E. ¼ of the N. W. ¼, area 38.6 acres, of Sec. 24, and the N. ½ of the N. W. ¼ of the N. W. ¼, Sec. 24.

42. German Road drain. Outlet into the Quanicassee river on the north side of Sec. 12, Merritt township, T. 13 N., R. 6 E. Drainage area in Sec. 12, the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 1, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 2, the S. ½ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec 11, the N. ½ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 10, the N. ½ of the N. E. ¼, and the N. ½ of the N. W. ¼; in Sec. 3, the S. W. ¼ of the S. E. ¼, the S. ½ of the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼; in Sec. 9, the E. ½ of the N. E. ¼, the N. ½ of the N. W ¼ of the N. E. ¼, the N. ½ of the N. E. ¼ of the N. W. ¼ and the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 4, the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼, the S. ½ of the S. E. ¼, the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 8, the N. ½ of the N. E. ¼, the N. ½ of the N. E. ¼ of the N. W. ¼; in Sec. 5, the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼, the S. ½ of the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 7, the N. E. ¼ and the N. W. ¼, the N. E. ¼ of the S. W. ¼; in Sec. 6, the S. ½ of the S. ½; in Sec. 1, T. 13 N., R. 5 E., the S. ½ of the S. E. ¼ and the S. E. ¼ of the S. W. ¼; in Sec. 12, the N. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, and the N. E. ¼ of the N. W. ¼.

43. Goetz drain. The outlet of this drain is on the county line between Bay and Saginaw, on the S. line of Sec. 18 into Souwestconing creek, T. 13 N., R. 5 E. The drainage area is as follows: The S. ½ of the S. W. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of Sec. 18, T. 13 N., R. 5 E. In Sec. 13, as follows, the S. E. ¼ and the S. W. ¼ and the S. ½ of the N. W. ¼, T. 13 N., R. 4 E. In Sec. 14, the N. ½ of the S. E. ¼ and the S. ½ of the N. E. ¼.

44. Goulette drain. The outlet of this drain is into the N. fork of the Kawkawlin river in the N. E. ¼ of the N. E. ¼ of Sec. 27, T. 15 N., R. 4 E., Kawkawlin township. The drainage area is as follows, in Sec. 27, the S. W. ¼ of the N. E. ¼, the S. ½ of the N. W. ¼; in Sec. 28, the S. E. ¼ of the N. E. ¼ and the S. W. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, and the N. ½ of the N W. ¼ of the S. E. ¼.

45. Gove drain. The outlet of this drain is into the Railroad drain in the S. E. ¼ of the N. E. ¼ of Sec. 3, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in Sec. 3 is as follows: the W. ½ of the S. E. ¼ of the N. E. ¼, the W. ½ of the N. E. ¼ of the N. E. ¼ and the E. ½ of the N. W. ¼ of the N. E. ¼. In Fraser township, Sec. 34, T. 16 N. R. 4 E., there is drained the E. ½ of the S. W. ¼ and the W. ½ of the S. W. ¼; in Sec. 33, the S. E. ¼ and the S. E. ¼ of the S. W. ¼.

46. Grass Creek drain. The outlet of this drain is into the Quanicassee and Cheboyganing state drain, on the N. line of Sec. 27, Merritt township, T. 13 N., R. 6 E. Drainage area in Bay county is as follows: In Sec. 25, the E. ½ of the N. E. ¼, and the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. ½ of the N. W. ½; in Sec. 24, the S. ½ of the S. E. ¼, the S. E. ¼ of the S. W. ¼ and the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 23, the S. ½ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 26, the N. ½ of the N. E. ¼ of the N. E. ¼, the W. ½ of the N. E. ¼, the N. W. ¼; in Sec. 27, the N. E. ¼ of the N. E. ¼ of the N. E. ¼.

47. Hampton and Bay Shore drain. Outlet of this drain is into Saginaw bay on the line between Secs. 8 and 9, Hampton township, T. 14 N., R. 6 E. Drainage area is as follows: in Sec. 8, the S. ½ of the N. E. ¼ of the S. E. ¼, the S. ½ of the N. E. ¼; in Sec. 9, the

S. W. ¼ of the S. W. ¼; in Sec. 17, the N. E. ¼ and the S. E. ¼; in Sec. 16, the W. ½; in Sec. 21, the N. W. ¼ of the N. W. ¼; in Sec. 20, the N. ½ of the N. ½; in Sec. 17, the S. W. ¼; in Sec. 18, the S. ½ of the S. E. ¼; in Sec. 19, the N. E. ¼.

48. Hellmuth drain. The outlet of this drain is into the German Road drain at the N. ¼ post of Sec. 8, Merritt township, T. 13 N., R. 6 E., and the S. ¼ post of Sec. 8, where it empties into the Russell drain. Drainage area as follows: The S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼, in Sec. 8. Also in the same Sec., the N. ½ of the S. ½ of the S. W. ¼, the N. ½ of the S. W. ¼, the S. ½ of the N. W. ¼, the S. ½ of the N. ½ of the N. W. ¼.

49. Histed drain. The principal outlet of this drain is into the German Road drain at the N. E. cor. of Sec. 8, Merritt township, T. 13 N., R. 6 E. This drain is also intersected by the Russell drain at the N. E. corner of Sec. 17, same township and range which would form an outlet E. into the Quanicassee river. The drainage area is as follows: In Sec. 8, the S. ½ of the N. E. ¼ of the N. E. ¼, the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, the N. ½ of the S. E. ¼ of the S. E. ¼; in Sec. 9, the S. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the N. W. ¼ of the S. W. ¼, the N. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 16, the S. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the N. W. ¼ of the S. W. ¼, the N. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 17, the S. ½ of the N. E. ¼ of the N. E. ¼, the S. ½ of the N. E. ¼, the N. ½ of the S. E. ¼, the N. ½ of the S. E. ¼ of the S. E. ¼.

50. Hopler Creek drain. The outlet of this drain is into the south fork of the Kawkawlin river in the S. E. ¼ of the N. W. ¼ of Sec. 12, Williams township, T. 14 N., R. 3 E. The drainage area includes the following land subdivisions: The S. W. ¼ of the N. W. ¼ of Sec. 12; in Sec. 11, the S. E. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, the N. W. ¼ of the S. W. ¼, the S. W. ¼ of the N. W. ¼; in Sec. 10, the S. E. ¼, the S. E. ¼ of the N. E. ¼, the S. ½ of the S. W. ¼ of the N. E. ¼, the S. W. ¼ of Sec. 10; in Sec. 9, the S. E. ¼ and the S. ½ of the S. W. ¼; in Sec. 16, the N. E. ¼, the W. ½ of the S. E. ¼, the N. W. ¼ and the S. W. ¼; in Sec. 17, the N. ½ of the S. E. ¼, the S. ½ of the N. E. ¼; in Sec. 20, the W. ½ of the N. E. ¼, the W. ½ of the S. E. ¼, the S. W. ¼; in Sec. 29, the W. ½ and the W. ½ of the E. ½; in Sec. 30, the E. ½; in Sec. 31, the N. E. ¼ of the N. E. ¼; in Sec. 32 the N. ½. This drain has not been dug. The lower reaches of the drainage area given is occupied by swamp land situated E. of the Tittabawassee moraine.

51. Hopp drain. The outlet of this drain is into the Russell drain at the N. ¼ post of Sec. 15, Merritt township, T. 13 N., R. 6 E. The drainage area is as follows: The S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼, all in Sec. 15. Also in the same section the S. ½ of the N. E. ¼ of the N. W. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼ the N. ½ of the S. E. ¼ of the S. W. ¼.

52. Indian Town drain. The outlet of this drain commences at a point on the N. bank of the Kawkawlin river where the E. line of Lot 3, Sec. 5, T. 14 N., R. 5 E., intersects same. This is in the S. W. ¼ of the N. W. ¼ of said Sec. 5. The drainage area embraces the following lands: The N. W. ¼ of the N. W. ¼ of Sec. 5; in Sec. 6, the N. E. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼ of the N. E. ¼. Secs. 5 and 6 are in T. 14 N., R. 5 E. In Sec. 31, T. 15 N., R. 5 E, there is drained the S. W. ¼ of the S. E. ¼, the W. ½ of the S. E. ¼ of the S. E. ¼, the S. W. ¼; in Sec. 36, Kawkawlin township, T. 15 N., R. 4 E., there is the N. E. ¼ and the N. W. ¼ of the S. E. ¼, also the N. E. ¼ of said section.

53. Jonas drain. The outlet of this drain is into the Town Line drain at the N. ¼ post of Sec. 4, Portsmouth township, T. 13 N., R. 6 E. The drainage area is as follows: In Sec. 4, the S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼. On the W. side of the drain the N. ½ of the S. E. ¼ of the S. W. ¼, the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the N. W. ¼ and the S. ½ of the N. E. fractional ¼ of the N. W. fractional ¼. This fractional ¼ has an area of 38.34 acres.

54. Jones drain. The outlet of this drain is into the Railroad drain on the line between Secs. 8 and 9, just N. of the N. 80-rod corner, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in Sec. 8 includes the S. ½ of the N. E. ¼ of the N. E. ¼, the S. E. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, and the S. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the S. W. ¼, the S. ½ of the N. W. ¼; in Sec. 7, the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼.

55. Keister drain. The outlet of this drain is into the Young drain in the N. E. ¼ of Sec. 31, Portsmouth township, T. 14 N., R. 6 E. The drainage area is the S. ½ of the N. E. ¼ of the N. E. ¼; the N. ½ of the S. E. ¼ of the N. E. ¼ in Sec. 31; in Sec. 32, the S. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼.

56. Kenney drain. This ditch has its outlet into the Quanicassee and Cheboyganing State drain on the N. line of Sec. 34, Merritt township, T. 13 N., R. 6 E. Lands which are tributary to this drain are as follows: In Sec. 34, the N. W. ¼ of the N. W. ¼; in Sec. 27, the S. W. ¼ of the S. W. ¼; in Sec. 28, the S. ½ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the E. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 33, the N. ½ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 32, the N. ½ of the N. ½; in Sec. 29, the S. ½ of the S. ¼, the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, and the S. ½ of the S. W. ¼ of the S. W. ¼. Where this drain is crossed by the Tuscola Stone road on the N. line of Sec. 32, T. 13 N., R. 6 E., there is a divide, the waters flowing E. and W. The western outlet of the drain is into the Treiber ditch at the N. W. corner of Sec. 32, T. 13 N., R. 6 E.

57. Kerr drain and extension. The outlet of this drain is into the north fork of the Kawkawlin river in the N. E. ¼ of the S. E. ¼ of Sec. 22, Kawkawlin township, T. 15 N., R. 4 E. The elevation here is 591.75 A. T. The drainage area in Sec. 22 includes the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the N. E. ¼; in Sec. 23 the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼; in Sec. 14, that part of the W. ½ of the W. ½ lying W. of the East Saginaw and Ausable Stone road; in Sec. 15, the S. E. ¼, the S. ½ of the N. E. ¼, the N. E. ¼ of the N. E. ¼, the S. ½ of the N. W. ¼ of the N. E. ¼; in Sec. 10, the S. E. ¼ of the S. E. ¼.

58. Kleinart drain. This drain has its outlet into the Quanicassee and the Cheboyganing State drain on the N. and S. ¼ line of Sec. 27, Merritt township, T. 13 N., R. 6 E. The drainage area in Sec. 27 includes the S. ½ of the S. E. ¼; in Sec. 34, the N. E. ¼, the W. ½ of the S. E. ¼, the E. ½ of the S. W. ¼.

59. Knodle drain. This drain has its outlet into the Ryon drain in the N. E. ¼ of the N. E. ¼ of Sec. 28, Frazer township, T. 16 N., R. 4 E. The drainage area in Sec. 28 includes the N. ½; in Sec. 21, the S. ½ of the S. W. ¼; in Sec. 20, the S. ½ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 29, the N. ½ in Sec. 30, the N. E. ¼ of the N. E. ¼; in Sec. 19, the S. E. ¼ of the S. E. ¼ of the S. E. ¼.

60. Kosciuszko drain. This drain has its outlet into Hopler creek, just N. of the W. ¼ post of Sec. 16, Williams township, T. 14 N., R. 3 E. The drainage area in Sec. 16 includes the N. W. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 21, the E. ½ of the N. W. ¼ of the N. W. ¼, the E. ½ of the N. W. ¼, the E. ½ of the S. W. ¼ of the N. W. ¼. South of the Midland Stone road in the same Sec. 21 there is the E. ½ of the S. W. ¼, the E. ½ of the E. ½ of the S. W. ¼, the W. ½ of the S. E. ¼; in Sec. 28, the W. ½ and the W. ½ of the E. ½; in Sec. 33, the N. E. ¼ of the N. W. ¼, the N. W. ¼ of the N. E. ¼.

61. Kraner drain. This drain empties into the Monitor drain on the N. 80 rod line of Sec. 23 in the N. E. ¼ of Monitor township, T. 14 N., R. 4 E. The drainage area includes the E. ½ of the S. E. ¼ of the N. E. ¼ of Sec. 23; in Sec. 24, the S. W. ¼ of the N. W. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, and the N. W. ¼ of the S. W. ¼.

62. Lapan drain. This drain has its outlet into the Bedell drain on the line between Secs. 20 and 21, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in Sec. 20 includes the following subdivisions: The S. ½ of the S. E. ¼ of the N. E. ¼, the E. ½ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 30, the N. E. ¼ of the N. E. ¼; in Sec. 29, the N. ½ of the N. ½, in Sec. 28, the N. W. ¼ of the N. W. ¼; in Sec. 21, the N. W. ¼ of the S. W. ¼, the W. ½ of the S. W. ¼ of the N. W. ¼.

63. LaPaussee drain. This drain has its outlet into Saginaw Bay on the line between Secs. 6 and 7, Frazer township, T. 16 N., R. 5 E. The drainage area in Sec. 1, T. 16 N., R. 4 E., is as follows: The S. ½ of the S. ½; in Sec. 12, the N. ½ of the N. ½ of the N. ½; in Sec. 11, the N. ½ of the N. ½ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 2, the S. W. ¼, the S. ½ of the S. E. ¼.

64. Lehman drain. This drain has two outlets. The northerly one into the Town Line drain at the N. E. corner of Sec. 3, Merritt township, T. 13 N., R. 6 E.; the southerly one into the German Road drain at the S. E. corner of Sec. 3. This drain is also bisected by the Schoof drain emptying into the Quanicassee river. The drainage area in Sec. 3 includes the S. ½ of the N. E. fractional 40, area 39.65 acres, of the N. E. ¼, the S. E. ¼ of the N. E. ¼ excepting the lower half. The S. ½ of the N. E. ¼ of the S. E. ¼, the N. ½ of the S. E. ¼ of the S. E. ¼; in Sec. 2, the N. W. ¼ of the S. W. ¼ of the S. W. ¼, the S. W. ¼ of the N. W. ¼ of the S. W. ¼, the N. W. ¼ of the S. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼ of the N. W. ¼.

65. Lesperance drain. This drain was dug during the high water of May, 1884, when the shore of the bay extended W. to the N. and S. ¼ line of Sec. 24, T. 15 N., R. 4 E. At the present time the area between the former and present shore line is occupied by swamp land. The outlet, in May, 1884, was on the N. and S. ¼ line of Sec. 24 and 27 rods N. of the center of the section. The drainage area in Sec. 24 includes the S. ½ of the N. W. ¼, the N. ½ of the S. W. ¼; in Sec. 23, the S. ½ of the N. E. ¼, the N. ½ of the S. E. ¼, the S. E. ¼ of the N. W. ¼, that part lying E. of the East Saginaw and Ausable Stone road. In the N. E. ¼ of the S. W. ¼ the area E. of the same stone road.

66. Linwood drain. This drain empties into Saginaw Bay on the town line between Secs. 36 and 1, T. 15 N., R. 4 E. and T. 16 N., R. 4 E. This drain has not been dug. In Sec. 2, T. 15 N., R. 4 E., the drainage area includes the N. ½ of the N. ½; in Sec. 3, the N. ½ of the N. ½; in Sec. 4, the N. ½, and the N. W. ¼ of the S. W. ¼; in Sec. 5, the N. ½, the N. ½ of the S. E. ¼, also the N. ½ of the S. W. ¼; in Sec. 6, the N. E. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 1, Beaver township, T. 15 N., R. 3 E., the N. E. ¼ of the N. E. ¼; in Sec. 35, T. 16 N., R. 4 E., the S. ½ of the S. ½ of the S. E. ¼, also the S. ½ of the S. ½ of the S. W. ¼; in Sec. 34, the S. ½ of the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼; in Sec. 31, the S. ½ of the S. E. ¼, and the S. ½ of the S. W. ¼. In Garfield township, T. 16 N., R. 3 E., there is the S. E. ¼ of the S. E. ¼.

67. Livingston drain. This drain empties into Willard creek at a point 11.50 chains south and 21.80 chains east of the corner of Secs. 28, 29, 32, 33, Beaver township, T. 15 N., R. 3 E. The drainage area embraces, in Sec. 33, the S. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 32, the S. ½ of the N. E. ¼, the N. ½ of the S. E. ¼, the S. E. ¼ of the N. W. ¼, the S. W. ¼; in Sec. 31, the S. E. ¼ of the S. E. ¼.

68. McNelly drain. This drain has its outlet into the No. 1 drain in the S. W. ¼ of the S. E. ¼ of Sec. 28, T. 15 N., R. 4 E. The grade line of the drain is rather high and was apparently run for the purpose of draining a swamp situated in the center of Sec. 29. The drainage area is as follows in Sec. 28: The N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼, the N. ½ of the S. ½ of the S. W. ¼; in Sec. 29, the N. ½ of the S. E. ¼, the S. ½ of the N. E. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼.

69. Meed drain. This drain has its outlet into the Baxman drain at the W. ¼ post of Sec. 30, T. 14 N., R. 5 E. The drainage area is as follows: The W. ½ of the N. W. ¼ of Sec. 30, the S. ½ of the S. W. ¼ of Sec. 19.

70. Meger drain. The outlet of this drain is into the Russell drain at the N. ¼ post. of Sec. 16, Merritt township, T. 13 N., R. 6 E. The drainage area in Sec. 16 includes the N. E. ¼ of the S. W. ¼, the W. ½ of the N. W. ¼ of the S. E. ¼, the S. E. ¼ of the N. W. ¼, the W. ½ of the S. W. ¼ of the N. E. ¼, the E. ½ of the N. E. ¼ of the N.W. ¼, the W. ½ of the N. W. ¼ of the N. E. ¼.

71. Meiers drain. This drain empties into the Keister ditch at the E. ¼ post of Sec. 31, T. 14 N., R. 6 E. Drainage area in said Sec. 31 includes the S. ½ of the N. E. ¼, the S. E. ¼ of the N. W. ¼, the S. ½ of the S. W. ¼ of the N. W. ¼, the N. ½ of the S. E. ¼, the N. E. ¼ of the S. W. ¼, the E. ½ of the N. W. ¼ of the S. W. ¼, and the N. W. ¼ of the N. W. ¼ of the S. W. ¼.

72. Merrill drain. This drain empties into the Saginaw Bay on the line between Secs. 8 and 9, Hampton township, T. 14 N., R. 6 E. Along the E. line of Secs. 8 and 17 this drain has the same course as the Hampton and Bay Shore drain, which drain see for drainage areas. Between Secs. 20 and 21 this drain was continued in another direction and has the following drainage area: In Sec. 20, the E. ½ of the N. E. ¼ of the N. E. ¼, the S. ½ of the N. E. ¼, the S. E. ¼; in Sec. 29, the N. E. ¼; in Sec. 21, the W. ½ of the. W. ½.

73. Mills drain. This drain empties into the Bangor and Monitor State drain in the center of Sec. 7, Bangor township, T. 14 N., R. 5 E. The drainage area in said Sec. 7 includes the N. E. ¼, the N. ½ of the N. W. ¼ of the S. E. ¼, the N. E. ¼ of the S. E. ¼.

74. Michie Creek drain. This drain has its outlet into Saginaw Bay on the E. and W. ¼ line of Sec. 7, Frazer township, T. 16 N., R. 5 E. This drain follows a natural water course which has only been straightened out as far as the East Saginaw and AuSable State road. On the W. 80-rod line of Sec. 11, T. 16 N., R. 4 E. The drainage area in Sec. 12 includes the S. ½ of the N. E. ¼, the N. ½ of the S. E ¼, the S. ½ of the N. W. ¼, the N. ½ of the S. W. ¼; in Sec. 11, the S. ½ of the N. ½, the N. ½ of the S. ½; in Sec. 10, the S. ½; in Sec. 9, the S. ½; in Sec. 16, the N. ½; in Sec. 17, the N. ½; in Sec. 8, the S. ½ of the S. ½; in Sec. 7, the S. ½ of the S. ½; in Sec. 18, the N. ½; in Garfield township, T. 16 N., R. 3 E., the S. ½ of Sec. 12; in Sec. 13, the N. ½; in Sec. 14, the N. ½; in Sec. 11, the S. ½, and the S. ½ of the N. ½; in Sec. 10, the S. ½, and the S. ½ of the N. ½; in Sec. 15, the N. ½; in Sec. 9, the S. E. ¼; in Sec. 16, by way of a tributary, the N. E. ¼. On the E. line of Sec. 11 this drain has an elevation of 48 feet above the bay at its present elevation.

75. Monitor drain. In Sec. 1 of Monitor township, T. 14 N., R. 4 E., this drain has the same course as the Bangor and Monitor State drain into which it empties on the N. and S. ¼ line of Sec. 12, 40 rods N. of the center, T. 14 N., R. 4 E. The drainage area beyond this point is as follows: In Sec. 12, the E. ½ of the S. W. ¼ and the W. ½ of the S. W. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼; in Sec. 13, the W. ½, the S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the W. ½ of the S. E. ¼; in Sec. 14, the E. ½; in Sec. 23, the N. ½ of the N. E. ¼, the S. W. ¼ of the N E. ¼, the E. ½ of the N. W. ¼, the W. ½ of the S. E. ¼, and the E. ½ of the S. W. ¼.

76. Nickel drain has its outlet into the Garvie drain in the S. E. ¼ of the S. W. ¼ of Sec. 22, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in said Sec. 22 includes the S. E. ¼ of the S. W. ¼, the W. ½ of the S. W. ¼; in Sec. 21, the S. ½ of the N. E. ¼ of the S. E. ¼, the N. ½ of the S. E. ¼ of the S. E. ¼.

77. No. 1 drain. This ditch empties into the north fork of the Kawkawlin river in the S. E. ¼ of the S. E. ¼ of Sec. 27, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in said Sec. 27, includes the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. E. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 34, the N. ½ of the N. W. ¼; in Sec. 28, the S. E. ¼ of the S. E. ¼; in Sec. 33, the N. ½, and the N. ½ of the S. W. ¼; in Sec. 32, the N. ½ of the S. ½, the S. ½ of the N. ½, and the N. ½ of the N. ½; in Sec. 29, the S. W. ¼ of the S. W. ¼; in Sec. 31, the N. E. ¼; in Sec. 30, the S. E. ¼, the E. ½ of the S. W. ¼, the E. ½ of the N. W. ¼.

78. Phillips drain. This drain empties into the south fork of the Kawkawlin river on the line between Secs. 7 and 12, T. 14 N., R. 4 E. and T. 14 N., R. 3 E. This drain is ill adapted for its purpose. The drainage area includes, in said Sec. 12, the S. E. ¼ of the S. E. ¼; in Sec. 13, the E. ½; in Sec. 24, the E. ½. Secs. 12, 13 and 24 are in T. 14. N., R. 3 E. In T. 14 N., R. 4 E., Sec. 18, the W. ½ of the W. ½; in Sec. 19, the W. ½ of the W. ½.

79. Pinconning drain. This drain empties into the Saginaw Bay on the line between Secs. 7 and 18, T. 17 N., R. 5 E. This ditch has the following drainage areas: In Sec. 7, the S. W. ¼ of the S. W. ¼; in Sec. 18, the N. W. ¼ of the N. W. ¼. In T. 17 N., R. 4 E., the S. ½ of Secs. 12, 11, 10, 9; in Sec. 8, the E. ½ of the N. E. ¼ of the S. E. ¼, the S. ½ of the S. E. ¼, the S. ½ of the S. ½ of the S. W. ¼, the N. ½ of the N. ½ of Sec. 17; of Sec. 16, the N. ½ of the N. ½; the N. ½ of Sec. 15; the N. ½ of Sec. 14; in Sec. 13, that part of the N. W. ¼ lying W. of the E. Saginaw and Ausable State road; in Sec. 13, the N. ½ of the N. E. ¼.

80. Pommerville drain and Extension. This drain has its outlet into the Grass Creek drain at the N. ¼ post of Sec. 25, T. 13 N., R. 6 E. The drainage area in Sec. 25 has the N. W. ¼ of the N. W. ¼ of the N. E. ¼, the S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ and the S. E. ¼ of the N. E. ¼, the S. E. ¼, the E. ½ of the W. ½; in Sec. 36, the E. ½ and the E. ½ of the W. ½.

82. Quanicassee and Cheboyganing State drain. In its course in Bay county this drain has its outlet into the Quanicassee river or estuary in the N. W. ¼ of the S. W. ¼ of Sec. 12, T. 13 N., R. 6 E. The drainage area directly tributary to this in Sec. 13 is as follows: The N. W. ¼, the N. ½ of the N. W. ¼ of the S. W. ¼, the N. E. ¼ of the S. W. ¼; in Sec. 14, the S. ½ of the S. E. ¼, the N. E. ¼ of the S. E. ¼; in Sec. 23, the W. ½ of the N. E. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, the N. W. ¼ of the S. E. ¼; in Sec. 22, the S. E. ¼ of the S. E. ¼; in Sec. 27, the S. ½ of the N. E. ¼ and the S. ½ of the N. W. ¼, the N. ½ of the S. W. ¼, the N. ½ of the S. E. ¼; in Sec. 34, the S. ½ of the N. W. ¼, the N. W. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 33, the S. E. ¼.

83. Quarter Line drain. Empties into the Young drain at the N. ¼ post of Sec. 33, Portsmouth township, T. 14 N., R. 6 E. The drainage area in said Sec. 33 includes the W. ½ of the N. W. ¼ of the N. E. ¼, the E. ½ of the N. E. ¼ of the N. W. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the W. ½ of the S. W. ¼ of the S. E. ¼, the E. and N. ½ of the S. E. ¼ of the S. W. ¼, the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the N. W. ¼.

84. Railroad drain. This drain has its outlet into Saginaw Bay on the ¼ line of Sec. 1, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in Sec. 2 is the N. ½ of the S. E. ¼ and the S. ½ of the N. E. ¼, the N. ½ of the S. W. ¼, and the S. ½ of the N. W. ¼; in Sec. 3 the E. ½ of the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, the S. E. ¼ of the N. W. ¼, the N. ½ of the N. E. ¼ of the S. W. ¼, the N. W. ¼ of the S. W. ¼; in Sec. 4, the S. E. ¼, and the S. ½ of the S. E. ¼; in Sec. 9, the N. ½ of the N. E. ¼, the N. W. ¼; in Sec. 8, the N. ½ of the N. E. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 5, the S. ½ of the S. ½; in Sec. 7, the N. E. ¼ and the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. W. ¼; in Sec. 6, the S. E. ¼. Since that time the drain has been extended into Garfield township.

85. Ratell drain. This drain empties into the Bennett drain and the Grass Creek drain at the N. W. corner of Sec. 25, Merritt township, T. 13 N., R. 6 E. The drainage area in said Sec. 25 includes the W. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the W. ½ of the S. W. ¼; in Sec. 36, the N. W. ¼ of the N. W. ¼; in Sec. 35, the N. E. ¼ of the N. E. ¼; in Sec. 26, the S. E. ¼, the S. E. ¼ of the N. E. ¼, the E. ½ of the N. E. ¼ of the N. E. ¼.

86. Robbins drain. This drain has its outlet into the Cheboyganing creek on the E. and W. ¼ line of Sec. 35, Zilwaukie township, Saginaw county, T. 13 N., R. 5 E. The drainage area in Sec. 31, Merritt township, T. 13 N., R. 6 E., includes the S. ½ of the N.

½, and the N. ½ of the S. ½, taking into account the Vigor drain on the S. line of 31, which was never dug.

87. Rosebush drain. Empties into Saginaw Bay in the S. W. fractional ¼ of the S. W. fractional ¼ of Sec. 36, Frazer township, T. 16 N., R. 4 E. The drainage area in Sec. 35 includes the N. ½ of the S. ½, and the S. ½ of the N. ½ of said Sec. 35; in Sec. 34, the N. E. ¼ of the S. E. ¼, and the N. ½ of the S. E. ¼ of the S. E. ¼.

88. Russell drain. Has its outlet into the Quanicassee river on the N. line of Sec. 14, Merritt township, T. 13 N., R. 6 E. The drainage area in said Sec. 14 includes the N. ½ of the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. W. ¼, the E. ½ and the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 11, the S. W. ¼ of the S. E. ¼, the S. W. ¼; in Sec. 10, the S. ½; in Sec. 15, the N. ½ of the N. E. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. ½ of the N. W. ¼, and the S. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼; in Sec. 16, the E. ½ of the N. E. ¼ and the E. ½ of the W. ½ of the N. E. ¼, the N. ½ of the N. W. ¼ of the N. E. ¼, the W. ½ of the N. E. ¼ of the N. W. ¼, the E. ½ of the W. ½ of the N. W. ¼, the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 9, the S. ½ of the S. E. ¼, the N. E. ¼ of the S. E. ¼, the E. ½ of the N. W. ¼ of the S. E. ¼, the S. ½ of the S. ½ of the S. W. ¼; in Sec. 8, the S. ½ of the S. ½ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼, the S. ½ of the S. ½ of the S. W. ¼, the N. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 17, the W. ½ of the N. E. ¼ of the N. E. ¼; in Sec. 18, the N. ½, the W. ½ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 7, the S. ½ of the S. ½; in T. 13 N., R. 5 E., Sec. 12, the E. ½ of the S. ½ of the S. E. ¼; in Sec. 13, the N. E. ¼ of the N. E. ¼.

89. Ryon drain. This drain follows a natural water course emptying into Saginaw Bay on the N. 80-rod line of Sec. 26, Frazer township, T. 16 N., R. 4 E. The drainage area includes the S. fractional ½ of the N. fractional ½ of said Sec. 26, the S. ½ of the N. ½ of Sec. 26; in Sec. 27 the S. ½ of the N. E. ¼ of the N. E. ¼, the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the S· W. ¼ of the N. E. ¼, and the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. E. ¼ of the N. W. ¼; in Sec. 22, the S. ½ of the S. W. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼; in Sec. 28, the N. E. ¼ of the N. E. ¼ of the N. E. ¼; in Sec. 21, the E. ½ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼, the N. ½ of the S. ½ of the S. W. ¼, the S. ½ of the N. W. ¼; in Sec. 20, the W. ½ of the S. E. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼, the N. ½ of the S. E. ¼, and the N. ½ of the S. W. ¼; in Sec. 19, the S. ½, and the S. ½ of the N. ½.

90. Schimbine drain. This drain has its outlet into Davis creek in the N. W. ¼ of the N. E. ¼ of Sec. 28, Beaver township, T. 15 N., R. 3 E. The elevation here is 36 feet above the Bay. The drainage area includes the S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the S. ½ of the N. E. ¼ of the N. W. ¼, the S. ½ of the N. W. ¼ and the N. ½ of the S. W. ¼; in Sec. 29, the N. E. ¼ of the S. E. ¼, the S. E. ¼ of the N. E. ¼.

91. Schoeneck drain. Empties into the Russell drain at the S. ¼ post of Sec. 9, Merritt township, T. 13 N., R. 6 E. The drainage area includes the E. ½ and the N. ½ of the S. E. ¼ of the S. W. ¼, the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the N. W. ¼, the E. ½ of the N. E. ¼ of the N. W. ¼, the W. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the W. ½ of the S. W. ¼ of the S. E. ¼. This is all in Sec. 9.

92. Schoof drain. This drain has its outlet into the Quanicassee river on the E. and W. ¼ line of Sec. 1, Merritt township, T. 13 N., R. 6 E. The drainage area embraces the S. W. ¼ of the N. W. ¼ of said Sec. 1, and the N. W. ¼ of the S. E. ¼; in Sec. 2, the N. ½ of the S. E. ¼, the S. ½ of the N. E. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, the E. ½ and the N. ½ of the N. W. ¼ of the S. W. ¼, the E. ½ and the S. ½ of the S. W. ¼ of the N. W. ¼; in Sec. 3, the W. ½ of the N. E. ¼ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼, the S. ½ of the N. W. ¼, the S. W. ¼ of the N. E. ¼, the W. ½ and the S. ½ of the S. E. ¼ of the N. E. ¼.

93. Schumacker drain. Empties into the Quanicassee and Cheboyganing State drain on the N. line of Sec. 27, Merritt township, T. 13 N., R. 6 E. The drainage area is as follows: The N. ½ of the N. W. ¼ of the N. E. ¼ in Sec. 27, also in the same Sec. the N. ½ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the W. ½ of the S. E. ¼ of the N. W. ¼; in Sec. 28, the N. E. ¼, the E. ½ of the N. W. ¼, the E. ½ and the N. ½ of the N.W. ¼ of the N. W. ¼; in Sec. 21, the S. ½ and the E. ½ of the S. W. ¼ of the S. W. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. E. ¼; in Sec. 22, the S. ½ of the S. W. ¼, the S. W. ¼ of the S. E. ¼.

94. Schwab drain. This drain has its outlet into the Edsall drain at the N. E. corner of Sec. 8, Monitor township, T. 14 N., R. 4 E. The drainage area includes the S. E. ¼ of Sec. 5, the S. W. ¼ of Sec. 5, the S. ½ of the N. ½ of the same section, the S. ½ of Sec. 6, the S. ½ of the N. ½ of the same section.

95. Secord drain. This drain empties into Saginaw Bay on the N. line of Sec. 26, Frazer township, T. 16 N., R. 4 E. The drainage area includes the N. ½ of the N. ½ of the N. ½ of Sec. 26, the S. ½ of the S. W. ¼ of Sec. 23; in Sec. 22, the S. E. ¼.

96. Senay drain. Emptying into the Railroad drain on the N. and S. ¼ line of Sec. 3, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in said Sec. 3 includes the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 10, the N. W. ¼.

98. Schindahatte drain. This drain empties into the Young drain at the N. E. corner of Sec. 35, Portsmouth township, T. 14 N., R. 5 E. The drainage aıea in said Sec. 35 includes the E. ½ and the S. ½ of the N. E. ¼ of the N. E. ¼, the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, the E. ½ and the N. ½ of the S. E. ¼ of the S. E. ¼; in Sec. 36, the W. ½ and the S. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the N. W. ¼ of the S. W. ¼, the W. ½ of the S. W. ¼ of the S. W. ¼.

99. Simpson drain. The outlet of this drain is into the Town Line drain at the N. ¼ post of Sec. 5, Portsmouth township, T. 13 N., R. 6 E. The drainage area in said Sec. 5 includes the E. ½ of the N. E. ¼ of the N. W. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, the E. ½, the N. ½ of the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the N. W. ¼ of the N. E. ¼, the W. ½ of the S. W. ¼ of the N. E. ¼, the W. ½ of the N. W. ¼ of the S. E. ¼, the W. ½ of the S. W. ¼ of the S. E. ¼.

100. Skelton creek. This drain has not been dug. The levels of the creek end on the line between Secs. 4 and 5, T. 14 N., R. 3 E. The outlet of the creek is in the S. W. ¼ of the N. W. ¼ of Sec. 1, Williams township, T. 14 N., R. 3 E. The drainage area in Williams township is as follows: In Sec. 2, the N. ½ of said Sec.; in Sec. 3, the N. ½, and the N. ½ of the N. ½ of the S. E. ¼; in Sec. 4, the N. ½, and the N. ½ of the S. ½; in Sec. 5, the N. E. ¼, the S. ½ of the N. W. ¼, the N. ½ of the S. E. ¼, the S. W. ¼; in Sec. 6, the S. E. ¼, the S. ½ of the S. W. ¼; in Sec. 7, the N. ½ of the N. E. ¼, the N. W. ¼. In Beaver township, T. 15 N., R. 3 E., in Sec. 33, the S. ½ of the S. ½; in Sec. 34, the S. ½ of the S. ½; in Sec. 35, the S. ½ of the S. W. ¼.

101. Sloat drain. This drain has its outlet into the No. 1 drain on the E. line of Sec. 31, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in said Sec. 31 includes the S. ½ of the S. E. ¼ of the N. E. ¼, the S. E. ¼, the E. ½ of the S. W. ¼.

102. Smith drain. This ditch has its outlet into the Kerr drain on the N. ½ of the N. W. ¼ of the N. E. ¼ of Sec. 15, Kawkawlin township, T. 15 N., R. 4 E. The drainage area includes the N. W. ¼ of the N. E. ¼, the E. ½ of the N. W. ¼, the W. ½ of the N. W. ¼, in Sec. 15; in Sec. 16, the N. ½ of the N. E. ¼, the N. E. ¼ of the N. W. ¼; in Sec. 10, the S. E. ¼ of the S. W. ¼.

103. Smith Creek drain. This drain has its outlet into the north fork of the Kawkawlin river in the N. E. ¼ of the S. E. ¼ of Sec. 11, T. 15 N., R. 3 E. The drainage area includes the E. ½ of the N. E. ¼ of Sec. 11; in Sec. 2, the E. ½ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the N. E. ¼, the E. ½ of the N. W. ¼; in Sec. 1, the W. ½ of the S. W. ¼; in T. 16 N., R. 3 E., the W. ½ of Sec. 35, the W. ½ of the E. ½; in Sec. 34, the N. E. ¼; in Sec. 27, the S. E. ¼; in Sec. 26, the S. W. ¼ of the S. E. ¼, the S. W. ¼.

104. Squaconning, North Branch. This drain has its outlet at a point about 100 rods W. of the E. line of Sec. 3, T. 13 N., R. 4 E., and 33 feet N. of the N. E. line in said Sec. 3, running thence up stream following the natural water course. The outlet of the, drain into the Squaconning creek in the W. ½ of the S. E. ¼ of Sec. 2, 80 rods N. of the S. line of said section, T. 13 N., R. 4 E. The drainage tributary to this natural water course in said Sec. 2; the N. W. ¼ of the S. E. ¼, the N. ½ of the N. E. ¼ of the S. W. ¼, the N. ½ of the N. E. ¼ of the S. W. ¼, the S. W. ¼ of the N. W. ¼; in Sec. 3, the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the N. E. ¼, the W. ½ of the N. E. ¼, the N. ½ of the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the N. W. ¼, the W. ½ of the N. W. ¼; in Sec. 4, the N. E. ¼ of the N. E. ¼; in Sec. 34, T. 14 N., R. 4 E. the S. W. ¼ of the S. W. ¼; in Sec. 33, the S. ½, and the N. W. ¼; in Sec. 32, the S. ½, and the S. ½ of the N. E. ¼, the N. E. ¼ of the N. E. ¼; in Sec. 31, the S. E. ¼; in Sec. 6, T. 13 N., R. 4 E., the N. E. ¼.

106. Tobico drain. This drain was dug during the high water of May, 1884, when the lake extended to a point 30 rods W. of the N. ¼ post of Sec. 24, T. 15 N., R. 4 E. At the present time this area is occupied by a swamp to where the shore line now is. The outlet is into a swamp 30 rods W. of the N. ¼ post of Sec. 24. Drainage area includes in said Sec. 24, the N. ½ of the N. W. ¼; in Sec. 13, the W. ½ of the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 14, the S. E. ¼ of the S. E. ¼; in Sec. 23, the N. E. ¼ of the N. E. ¼.

107. Town Line drain. Commencing at the W. bank of the Quanicassee river at the N. E. corner of Sec. 1, Merritt township, T. 13 N., R. 6 E., which is the outlet of this drain. Drainage area in said Sec. 1 includes the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 2, the N. ½ of the N. ½; in Sec. 3, the W. ½ of the N. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 4, the N. E. ¼ of the N. E. ¼, the E. and N. ½ of the N. W. ¼ of the N. E. ¼, the W. ½ of the N. E.

¼ of the N. W. ¼, the W. ½ of the N. W. ¼; in Sec. 5, the E. ½ of the N. E. ¼, the E. ½ of the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. W. ¼, the W. ½ of the N. W. ¼; in Sec. 6, the N. E. ¼, the N. W. ¼ of the S. E. ¼, the E. ½ of the N. W. ¼, the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 1, T. 13 N., R. 5 E., the W. ½ of the N. E. ¼, the N. W. ¼; in Sec. 2, the N. E. ¼. In Sec. 36, Hampton township, T. 14 N., R. 6 E., the S. ½ of the S. E. ¼ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the S. W. ¼; in Sec. 35, the S. ½; in Sec. 34, the E. ½ of the S. E. ¼, the E. ½ of the W. ½ of the S. E. ¼, the S. ½ of the. S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 33, the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 32, the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 31, the S. ½ of the S. E. ¼ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 36, T. 14 N., R. 5 E., the S. ½ of the S. ½ of the S. E. ¼, the S. ½ of the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 35, the S. ½ of the S. E. ¼ of the S. E. ¼, the S. W. ¼ of the S. E. ¼.

108. Treiber drain. At the N. W corner of Sec. 31, Merritt township, T. 13 N., R. 6 E., this drain has its outlet into the Saginaw County drain, which I believe empties into the Cheboyganing creek on the N. line of Sec. 34, T. 13 N., R. 5 E The N. outlet of the drain is at the E. ¼ post of Sec. 18, T. 13 N., R. 6 E., where it runs into the Quanicassee river. The drainage area in Sec. 31 is the N. ½ of the N. W. ¼, the N. W. ¼ of the N. E. ¼, the N. ½ of the N. E. ¼ of the N. E. ¼; in Sec. 30, the S. ½, the S. E. ¼ of the N. E. ¼, the S. and E. ½ of the N. E. ¼ of the N. E. ¼; in Sec. 19, the E. ½ of the S. E. ¼ of the S. E. ¼, the N. E. ¼ of the S. E. ¼, the S. E. ¼ of the N. E. ¼, the S. and E. ½ of the N. E. ¼ of the N. E. ¼, in Sec. 18, the E. ½ of the S. E. ¼ of the S. E. ¼, the N. E. ¼ of the S. E. ¼; in Sec. 29, the W. ½ of the S. W. ¼ of the S. W. ¼, the N. W. ¼ of the S. W. ¼, the N. W. ¼; in Sec. 20, the S. W. ¼, the S. ½ of the N. W. ¼; in Sec. 17, the N. W. ¼ of the S. W. ¼.

109. Tromble drain. This drain empties into the Saginaw river on the N. line of Sec. 16, T. 13 N., R. 5 E. The drainage area is as follows: The S. ½ of the S. E. ¼ of Sec. 9; in Sec. 10, the S. ½ and the S. ½ of the N. W. ¼; in Sec. 11, the W. ½ of the S. W. ¼ and the W. ½ of the N. W. ¼, the S. E. ¼ of the S. W. ¼, the S. and E. ½ of the S. W. ¼ of the S. E. ¼, the E. ½ of the S. E. ¼; in Sec. 12, the S. W. ¼, and the S. W. ¼ of the S. E. ¼; in Sec. 13, the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 14, the N. ½ of the N. ½; in Sec. 15, the N. ½ of the N. ½.

110. VanAlstine drain. Empties into the Indian Town drain 40 rods S. of the N. E. corner of Sec. 6, T. 14 N., R. 5 E. The drainage area includes in Sec. 31 the S. and E. ½ of the S. E. ¼ of the S. E. ¼, the N. ½ of the S. E. ¼, the N. E. ¼ of the S. W. ¼, the N. ½ of the N. W. ¼ of the S. W. ¼, the S. ½ of the N. ½, the N. E. ¼ of the N. E. ¼; in Sec. 32, T. 15 N., R. 5 E., the W. ½ of the W. ½.

111. Vigor drain. This drain empties into the Cheboyganing on the S. line of Sec. 36, 74 chains W. of the S. E. corner T. 13 N., R. 5 E. The drainage area in Bay county includes, in Sec. 31, the S. ½ of the S. ½; in Sec. 32, the S. ½; in Sec. 33, the S. W. ¼; in Sec. 34, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼, the S. and E. ½ of the S. W. ¼ of the S. E. ¼ of the S. E. ¼ of the S. E. ¼, the S. ½ of the N. E. ¼ of the S. E. ¼; in Sec. 35, the S. ½ of the S. W. ¼, the S. E. ¼ of the S. E. ¼; in Sec. 36, the S. ½ of the S. W. ¼, the S. and E. ½ of the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S E. ¼.

112. Walther drain. This empties into Saginaw Bay on the N. and S. ¼ line of Sec. 7, T. 14 N., R. 6 E. In said Sec. 7 the drainage area includes the S. ½ of the S. W. ¼ of the N. E. ¼, the S. ½ of the N. W. fractional ¼, the N. W. ¼ of the S. E. ¼, the N. fractional ½ of the S. W. ¼, the S. W. ¼ of the S. E. ¼, the S. fractional ½ of the S. W. ¼; in Sec. 18, the N. W. ¼ of the N. E. ¼ and the N. fractional ½ of the N. W. ¼.

113. Wanderwilt drain. This drain has its outlet at the N. ¼ post of Sec. 36., T. 14 N., R. 5 E. The drainage area in said Sec. 36 includes the E. and S. ½ of the N. E. ¼ of the N. W. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, the N. and E. ½ of the S. W. ¼ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the S. W. ¼ of the N. E. ¼, the S. and W. ½ of the N. W. ¼ of the N. E. ¼.

114. Warner drain. This drain empties into the Saginaw Bay at the N. E. corner of Sec. 25, Hampton township, T. 14 N., R. 6 E. The drainage area in said Sec. 25 includes the N. ½ of the N. W. ¼ of the N. E. ¼, the N. W. ¼; in Sec. 26, the N. ½ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 23, the S. ½ of the S. ½; in Sec. 24, the S. W. ¼ of the S. W. ¼, the S. ½ of the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼.

116. Watt drain. This drain empties into the Brown drain at the N. ¼ post of Sec. 30, Merritt township, T. 13 N., R. 6 E. The drainage area includes the W. and S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼ of the S. E. ¼, the N. ½ of the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the N. W. ¼, the E. ½ of the N. E. ¼ of the N. W. ¼.

117. Webster drain. This drain has its outlet into a road ditch on the E. line of Sec.

4, Williams township, T. 14 N., R. 3 E. Drainage area the S. E. ¼ of said Sec. 4, the E. ½ of the S. W. ¼ of the same section.

118. Williams drain. This drain has its outlet into the Chute Creek drain in the S. E. ¼ of the N. E. ¼ of Sec. 4, T. 16 N., R. 4 E. Drainage area in said Sec. 4, the N. W. ¼ of the N. E. ¼, the N. ½ of the S. W. ¼ of the N. E. ¼, the N. W. ¼; in Sec. 5, the N. E. ¼.

119. Williams and Tittabawassee drain. This drain has its outlet into the Culver Creek drain of which it is a continuation. Commencing at a point 2.6 chains N. of the S. E. corner of Sec. 25, Williams township, T. 14 N., R. 3 E. The drainage area in said Sec. 25 includes the S. E. ¼ of the S. E. ¼; in Sec. 36, the N. E. ¼, the N. E. ¼ of the N. W. ¼, the S. ½ of the N. W. ¼, the S. W. ¼; in Sec. 35, the S. ½ of the S. ½; in Sec. 34, the S. ½ of the S. ½ of the S. E. ¼, the S. ½ of the S. ½ of the S. W. ¼. The drainage area in Saginaw county is not here given.

120. Young drain. This drain empties into the Center Avenue dredge cut on the E. line of Sec. 27, Hampton township, T. 14 N., R. 6 E. Elevation here is 584.3 A. T. The drainage area in said Sec. 27 includes the E. ½ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼; in Sec. 34, the N. ½ of the N. E. ¼, the W. ½ of the N. E. ¼, of the N. W. ¼, the N. W. ¼ of the N. W. ¼; in Sec. 28, the S. ½ of the S. ½; in Sec. 29, the S. ½ of the S. ½; in Sec. 30, the S. ½ of the S. ½; in Sec. 25, T. 14 N., R. 5 E., the S. ½ of the S. ½; in Sec. 26, the S. E. ¼ of the S. E. ¼; in Sec. 33, T. 14 N., R. 6 E., the E. ½ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, the N. ½ of the N. E. ¼ of the N. W. ¼, and the E. and N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 32, the W. ½ of the N. E. ¼ of the N. E. ¼, the E. ½ of the N. W. ¼ of the N. E. ¼, the N. and W. ½ of the N. E. ¼ of the N. W. ¼, the E. and N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 31, the N. ½ of the N. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. W. ¼, the N. ½ of the N. W. fractional ¼ of the N. W. fractional ¼; in Sec. 36, the N. and W. ½ of the N. E. ¼ of the N. E. ¼, the E. and N. ½ of the N. W. ¼ of the N. E. ¼, the N. and W. ½ of the N. E. ¼ of the N. W. ¼, the E. and N. ½ of the N. W. ¼ of the N. W. ¼. Sec. 36 is in T. 14 N., R. 5 E.; in Sec. 35, same township and range, the N. and W. ½ of the N. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, the N. W. ¼.

CHAPTER VI.

ECONOMIC GEOLOGY, ESPECIALLY WATER SUPPLY.

1. *Introduction.*

In chapters II, III and IV we had occasion to review the geology of the underlying sedimentary formations of Bay county, the coal measures with its associated beds of shale and iron carbonate, and finally in chapter IV the soil and sub-soil formations. It is the purpose of this chapter to draw more particular attention to the raw products associated with the drift and underlying consolidated formations which were described there.

2. *Salt Industry.*

In Volume III, Appendix B, of the series of quarto reports of the Michigan Geological Survey, Dr. S. S. Garrigues, for several years State Salt Inspector, contributed a report on the production of salt in the Lower Peninsula. This was printed in 1876. In the year 1895, Lucius L. Hubbard, State Geologist, wrote an introduction on the "Origin of Salt, Gypsum and Petroleum," which appeared in Volume V, Part 2, of the same series of state reports. For information concerning the chemistry of salt and a general description of the subject, the reader is referred to the preceding reports. The earliest extensive treatment of the salt manufacture in the Saginaw valley was by Dr. H. C. Hahn in the "Berg-und-Huettenmaennische Zeitung" for 1867, in a series of articles running through the year from page 97 to page 339. Dr. Hahn was located in the New York and Saginaw works in Saginaw county, and it is intended to give a full account of his tests in the Saginaw county report.

At Bay City brines have been utilized from three sandstone horizons, namely: The Parma sandstone at a depth of about 600 feet; the Marshall sandstone at about 900 feet, but varying considerably in elevation north and south of the Middle Ground; and the Berea Grit at a depth in the neighborhood of 2,100 feet. At the Atlantic Mill, and in the deep well at South Bay City, brines from the Berea reached the surface from an average depth of 2,200 feet. A third well was put down on the west side near 28th street. Unfortunately the deep well at South Bay City was not put down into the underlying Salina beds of the Monroe formation, which contain beds of rock salt throughout the greater portion of Lower Michigan. Brines from the Marshall or Berea are remarkably free from calcium sulphates and not likely to cake. On the other hand, rock salt brines contain more lime, especially the sulphate, which produces caking. This is again counterbalanced by the fact that the natural brines contain earthy chlorides so that a large amount of the bittern must be thrown away. In Bay City a valuable disinfectant is said to be made from this bittern. An analysis of this as contained in one gallon of 231 cubic inches, in grains, was given me by Mr. E. S. Fitch of Bay City.

Alumina sulphate	33.6882 grains
Alumina chloride	1693.8770 grains
Magnesium bromide	1169.1127 grains
Magnesium chloride	475.4984 grains
Sodium chloride	537.4984 grains
Calcium chloride	1372. 5135 grains

Among the most important by-products in the manufacture of salt are soda, potash and bromine, the latter of which is the base of the best photograph paper. The soda-ash business is one of the foundation stones of chemical industries.

We herewith present analyses of the three principal brines from the Parma, Marshall and Berea horizons, as follows:

Parma, Gilmore well, Bay City, Michigan. Depth of well, 505 feet. Brine 65° by salinometer.

Sulphate of lime (gypsum)	0.3961
Chloride of calcium	0.5302
Chloride of magnesium	.4115
Chloride of sodium (salt)	15.2674
Saline matter	16.6052
Water	83.3948
	100.0000

South Bay City, Deep Well, Marshall, flow at 900 feet. Specific gravity 1.186, 295 total solids per liter.

$Ca\,SO_4$	0.07 per 100 grams
$Ca\,Cl_2$	3.4
$Mg\,Cl_2$	1.35
K Na	19.9

South Bay City, Berea, Analysis of flow at 2,200 feet by Dr. Zahorski of the North American Chemical Co.

Na Cl	186.19 grams per liter
Ca Cl	110.60
$Mg\,Cl_2$	33.47
$Ca\,SO_4$	0.30
Fe_2O_3	1.14

3. *Shales and Fire Clay.*

In Volume VIII, Part 1, H. Ries has partially described the clays and shales of Michigan, with an account of their properties and uses. To obtain a perspective of this subject, and a proper idea of the relationship of the shale beds of Bay county to that of the rest of the state, the reader is referred to that report.

In connection with the description of the coal formation in Bay county, we had occasion to describe certain beds of fire clay or shale, but generally identified as slate by the drillers, to whom we are indebted for our records. These shale beds are almost invariably found associated with beds of coal, but also occur where the coal is wanting.

There are also massive beds of shale in the Coldwater formation, which are found at a depth of from 1,200 to 2,000 feet. Where these beds outcrop at the surface, as in Branch county, they are utilized in the manufacture of Portland cement. Outcrops of this formation are also found on the Lake Huron shore in the southeastern part of Huron county. On account of the convenience of water transportation, the time is probably not far distant when this shale will be assembled with limestone or marl, brought down from the north to Bay City, and made into Portland cement, brick, and other products which depend upon clay and shale for raw material. These Coldwater shales probably run too low in siliceous matter to be burnt for road metal. In such manufactures, the assembling point is determined by transportation, fuel and accessibility to the market. In these regards Bay City is rather a strategic point. As we shall see, however, shale beds more or less suitable in quality, are found with workable beds of coal in Bay county.

Without taking into consideration the marl or limestone which forms approximately 65% of the Portland cement mixture, there are certain desirable qualities which it is necessary that the clay should possess for utilization in the cement business. Prof. Delos Fall informs me that an ideal clay for such purposes should contain 60% of the oxide of Silicon (SiO_2), 17% of Al_2O_3 and 3% of iron oxide. In other words the oxides of iron and alumina form ⅓ of the entire amount of SiO_2[1]. Clays should contain very little free sand, iron oxide, or organic matter. The silica must be combined and not free. It should have a tendency to gelatinize when treated with acids. The presence of over 2% of magnesium oxide (?) or sulphuric acid in the form of calcium sulphate, is deleterious on account of the tendency to partially dissolve and thus lead to the final disintegration of the proposed structure.[2]

In the above remarks, we only had occasion to notice the chemical properties of clay in regard to their adaptation to the cement business. In Volume VIII, Part 1, H. Ries has described the properties of clay more particularly in reference to their use for brick, tiling, crockeryware, and other allied industries. While the properties which render clay and shale valuable for cement purposes are largely of a chemical nature, their use for other purposes depends not only on such properties, but also on certain physical tests such as slaking, plasticity, behavior under heat, shrinkage in drying and burning, color, and tensile strength.[3] Just as the chemical tests are more important in the cement business, so are the physical properties more important for the other purposes already outlined. For further information regarding these properties, the reader is referred to the above report.

At the mine of the Central Coal Mining Co., and at several other localities in Bay county, Mr. Ries examined and reported on beds of shale which underlies the Upper Verne seam there:

"This underlying clay at the Central Co. is quite homogeneous, and resembles somewhat that found at the Standard shaft near Saginaw (an earlier formation), but is much softer, being easily cut with the blade of a knife. It is stated that this clay was at one time tried for the manufacture of bricks at Saginaw and gave good results."

"Unlike most of the other shales found with the coals in this region, it slakes in water though slowly. It has a somewhat sandy appearance, and contains numerous small mica scales."

[1]The amount of silica can run somewhat higher if the ratio holds. Also the relative amount of iron oxide and alumina can vary together, if the total equals ⅓ the amount of silica.

[2]Delos Fall, Michigan Geological Survey, Volume VIII, part 3, p. 344.

[3]Michigan Geological Survey, Volume VIII, part 1, p. 2.

"It took 19% of water to work it up to a lean but not granular mass, whose air shrinkage was 5%."

"The tensile strength of the air dried briquettes was from 50 to 60 pounds per square inch, and the soluble salt contents, 3%."

"In burning at cone 05 (1922° F.), the total shrinkage was 6%, but incipient fusion was not attained until cone 1 (temp. 2102°), with a total shrinkage of 7%, the color of the bricklet being cream." At cone 4 (2210° F.) the shrinkage was 9% and the color of the brick the same. Vitrification took place at 5 (2246°), and above this the clay burned to a grayish color, beginning to show signs of viscosity on the part of the larger ferruginious patches at cone 8 (2354°). The brick as a whole did not fail until cone 11 (2462°)."

At the mine of the Michigan Coal & Mining Co,. situated a short distance northwest of the Central Coal and Mining Co., and west of Salzburg, the upper shale under the coal (Lower (?) Verne), forms a layer two to three feet thick. It grades downward into a bluish-black shale.

"The under shale resembles somewhat that found at the Central Co's shaft. While the two types found under the coal both appear hard when dry, still they differ in plasticity, as already noted, when freshly mined, and this difference also shows itself in their further physical behavior."

"The upper part of the under clay behaves as follows: Water required to temper, 25%; air shrinkage of bricklets, 6%; tensile strength of air dried briquettes, 150 to 175 pounds per square inch; incipient fusion reached at cone 05 (1922°), with total shrinkage of 9%, vitrification at cone 1(2102° F.) and viscosity at 5 (2246°). Soluble salts 2%."

"The bottom layer, on the other hand, does not slake as readily as the preceding one. It shows no mica nor pyrite. In mixing it up only 17% of the water was required, and the resulting mass was granular and lean; it could be dried rapidly without cracking. The air shrinkage was 4%, and the tensile strength of the air dried briquettes ranged from 55 to 60 pounds per square inch. The soluble salts were 7%. The clay burns red at cone 06 (1850° F.) and vitrified at 2 (2138°),"

The shaft of the Wenona Coal Co's. mine terminates in the Upper Verne seam, and is underlain by light colored shale, and overlain by black fissle shale (the miners' slate). The thickness of the upper shale is said to vary from two to 10 feet.

"A sample of this material (undershale) was tested with the following results: It gave no effervescence with hydrochloric acid, and showed little or no pyrite, but scales of mica were not uncommon in it. When thrown into water it slaked little or none."

"In working it up, 18% of the water was required, giving a mass of low plasticity, whose air drying could be carried on rapidly, and was accompanied by 3½% of shrinkage."

"The tensile strength of the air dried briquettes was also low, amounting to an average of 55 pounds. The soluble salts were .6%."

"In burning, incipient fusion took place at cone 2 (2138°), with a shrinkage of but 4%, vitrification at 6 (2282°), and viscosity at 8 (2354). The shale burned red."

This over shale is to be compared with that first described as underlying the same seam of coal at the Central Coal Co's. shaft west of Salzburg.

"At the shaft of the Monitor Coal Co., the overlying shale is similar to that at the Wenona Coal Co's. shaft, but contains more bituminous matter." The two localities are on the some geological horizon, i. e., the Upper Verne coal. The fire clay at the Monitor Coal Co's. shaft, now abandoned, but worked from the south in the entries from Bay No. 2 mine, is said to average 8 to 10 feet in thickness.

"A carload of these two shales was sent to Saginaw some time ago for testing, and found to yield very favorable results."

As will be noticed by referring to the chapter on coal, almost all the mines now running in Bay county are in the Upper Verne seam. We should consequently expect the above determinations to hold essentially for most of the mines now in operation. An exception to this is to be noted in the sample from the Michigan Coal and Mining Co's. shaft in the Lower Verne seam, now reached in three shaft holes in Bay county.

The following analyses by A. N. Clark are respectively from the shale under the Upper Verne coal at the Wenona mine, and for the upper part of the under clay in the mine of the Michigan Coal and Mining Co. of the Lower Verne (?) seam.

Silica, $Si\,O_2$	52.45	57.0
Alumina, $Al_2\,O_3$	23.27	20.02
Iron as Fe_2O_3	7.93	8.18
Lime as $Ca\,CO_2$	1.82	0.71
Mg. as $Mg\,CO_2$	1.06	1.47
Alkalies as K_2O	4.37	2.76
Difference largely H_2O and organic	9.10	9.76
	100.00	100.00
Ferrous iron as FeO	1.57	1.47

I am indebted to Mr. A. C. Lane for the following description of the brick plant of the Michigan Vitrified Brick Co.

"The new brick plant is right by the old one at the Valley Coal Co. on Dutch creek (Squaconing creek). They expect to make fire brick and paving brick. The section underneath the coal shows four and a half feet of fire clay and six feet of shale. They use half and half for paving brick."

"They now have two of the older kilns running of the E. U. Daley (?) pattern. The shale goes first to a dry grinder, then to a Berg press, dry process. They are giving 80 tons pressure, and the capacity is 20,000 bricks per day. They have two down draft kilns, one circular and one square."

"This is the present plant, and the fire brick which they are now making they are planning to use in their own kilns. For the clay mining they pay 20 cents a ton. In Ohio 18-20 cents is said to be paid."

"The new plant will, after the shale has been through the dry grinder, take it to a Bonnont No. 4 pug mill and die having a capacity of from 50,000 to 75,000 per day. Automatically the square stream of clay is forced through the die and goes on to the table where it is cut off by wires, side cut. Then it passes on to the represser, then into the drying tunnels 126 feet long, which it slides through on cars still by gravity, with a slope of one inch in seven feet. It takes from 24 to 48 hours to go through. These are fed by waste heat, the air fed to the fan can be heated by some 9,000 feet of radiation. There are sub-tunnels for the last 40 or 50 feet through which the air is fed in.

"Then the brick is automatically conveyed to 90-foot long kilns. Five of them cost $5,000 each, and the total cost of the entire plant is $150,000. The tunnels, etc., are not of as large capacity as the Bonnont mill. So there may be enlargement soon."

For the following shale and clay analyses made by Lathbury & Spackman, I am indebted to Mr. U. R. Loranger of the Hecla Portland Cement and Coal Co. plant of Bay City. Unfortunately the amount of sulphuric anhydride is not stated by them.

The following shale analysis is from coal test hole record number 85. I believe that it is from the shale underlying the Lower Verne in the N. W. ¼ of the S. E. ¼ of section 2, T. 13 N., R. 4 E.

Silica, $Si\,O_2$	65.24%
Alumina, iron oxide, Fe_2O_3, Al_2O_3	23.56
Lime, Ca O	None
Magnesia, Mg O	1.11
Loss on ignition	6.72
	96.63

For cement purposes this shale is to be recommended for its low content of lime and magnesia. While the amounts of oxides of iron and alumina is about 1.8% too high for the amount of silica content, the relative amounts hold fairly well for a cement shale.

This analysis is from a surface clay from the Michigan Clay Co. in the S. E. ¼ of section 7, T. 13 N., R. 5 E.

Silica, $Si\,O_2$	44.60%
Iron and alumina, Fe_2O_3, Al_2O_3	13.11
Lime, Ca O	11.47
Magnesia, Mg O	7.09
Loss on ignition	17.91
	94.18

Whether the sand is free or combined in this material, is not stated. The oxides of lime and magnesia, however, are altogether too high for this cement purpose. It is also probable that the lime content would unfit it for making brick on account of its tendency to burst and crack.

A similar analysis is from the Williams Clay Co. just north of this last locality.

Silica, $Si\,O_2$	40.76%
Iron, Alumina, Fe_2O_3, Al_2O_3	15.39
Lime, Ca	12.83
Magnesia, Mg O	6.83
Loss on ignition	18.35
	94.16

The following analysis is probably from one of the coal shafts in section 25 of Monitor township. It is comparable to the analysis made by A. N. Clark of the shale below the Upper Verne, in the same vicinity.

Silica, $Si\,O_2$	51.40%
Alumina, iron oxide, Al_2O_3, Fe_2O_3	29.30
Lime, Ca O	.15
Magnesia, Mg O	2.23
Sulphur	0.79
Loss on ignition	11.84

For cement purposes the amount of silicate is too low, and that of the oxides of iron and alumina too high. The content of magnesia is also greater than is desirable for such purposes. This shale, however, is very probably on the same horizon as the shale that is being used at the Valley Mine for the manufacture of vitrified brick.

The two following analyses are probably associated with the Lower Verne coal in the Hecla shaft (?) in section 2 of Frankenlust township.

Silica, $Si O_2$	61.13%
Alumina, iron oxide, Al_2O_3, Fe_2O_3	26.90
Lime, Ca O	.12
Magnesia, Mg O	.96
Loss on ignition	6.47
	95.58

Except for the too high amount of oxides of iron and alumina, the shale given above would be adapted for cement manufacture. It would be better to have the percentage of iron and alumina stated separately. This is a light shale probably underlying the Lower Verne coal.

The following is a dark shale from the same (?) locality.

Silica, $Si O_2$	54.93%
Alumina, iron oxide, Al_2O_3, Fe_2O_3	31.43
Lime, Ca O	.22
Magnesia, Mg O	1.58
	88.16

Prof. F. S. Kedzie of the Michigan Agricultural College made the following analysis of a shale bed on property leased by the Hecla Portland Cement and Coal Co. It is very nearly an ideal material for this purpose except for the rather high percentage of sulphuric anhydride and iron oxide.

Silica, $Si O_2$	58.95%
Alumina, Al_2O_3	14.45
Iron oxide, Fe_2O_3	7.60
Lime, Ca O	2.94
Magnesia, Mg O	.86
Sulphuric anhydride, SO_3	1.73
K_2O	2.54
Water of combination	7.50
Organic matter and loss	3.43
	100.00

4. *Road Metal.*

The black shale overlying the Upper Verne coal has been burnt, and used for road metal in Frankenlust township. I am told that the result is quite satisfactory. The large amount of this material on the dumps of the different Bay county mines could very probably be used to advantage in this way. If a mill is ever established for this purpose, I believe that it would be advantageous to have the material crushed to about the size of coarse gravel, before burning. Similar use of this black shale has been made at

Jackson. At St. Charles the shale overlying the Saginaw coal has been put on the road without burning, with not so good results.

Other road metal material has been obtained from the surface deposits of Bay county. In this way the Kawkawlin stone road has been improved near its intersection with the Railroad drain in the northern part of Kawkawlin township. The material was obtained from beach washings on the shore of Saginaw bay near Linwood.

A gravel-sand deposit crosses the north line of section 6 Kawkawlin township, meandering north and south near the house of August Gregoire, in section 31 of Fraser. This material drains and packs well, but would very likely be further improved by screening. For local purposes it might very well be utilized, as for instance on the road leading west from Linwood.

In the chapter on soils and sub-soils, attention was directed to another sand and gravel beach running north, a short distance east of Bently. I believe that this deposit could be used by the Bay County Stone Road Commission in their prospective improvements in Pinconning, Mt. Forest and Gibson townships, if not farther south. Gravel deposits also occur one mile north of Gladwin, near that branch of the Michigan Central running west from Pinconning, and through Mt. Forest township.

With the utilization of the above mentioned surface deposits in the northern part of the county, and other road metal to be obtained from the mines in the latitude of Bay City, the development of the county stone roads could probably be more economically and expeditiously carried on than heretofore. Crushed erratics or cobbles also make a very excellent road material which could be used to a limited extent.

An ideal road metal is found in the trap rock of Mt. Bohemia near Lac La Belle in Keweenaw county. The rock is hard with good cementing qualities and has but very little dust. The transporting facilities by water being favorable, the time may come when it will be found profitable to use on our Bay county roads, even if it could not now be used to advantage. The U. S. Department of Agriculture is engaged in making tests of road material gratis. This department has published Bulletin No. 79, on "The Testing of Road Materials," which may be obtained on application.

The specific gravity and weight per cubic foot are coordinates. I presume these factors are given in order to determine the weight as relative to the comparative efficiency of the rock, as determined by the hardness, toughness, and cementing value of the material used. Where road metal is shipped considerable distances, this factor would enter into consideration as compared with the results obtained, as shown by the per cent of wear. The latter factor is again the visible result of the three principal physical characters, hardness, toughness and cementing value.

The absorption test is not intended to give the porosity, but merely the number of pounds of water that is absorbed by a cubic foot of rock in 96 hours. This factor is important in connection with the effect of freezing on road materials. "It is very doubtful whether the effects of freezing is injurious to road materials that absorb water even in considerable amounts, but at all events it is probably very small when compared with the destruction wrought by this same agency on the road bed as a whole. One hundred volumes of water expand on freezing to 109 volumes of ice. If expansion is prevented, the pressure developed on cooling the water 1° below its normal freezing point, is 144 tons per square foot. When we examine the subject closely it becomes apparent that the action of frost on road materials is not so great as it at first seems."[1] A table is given showing the percentage of water absorbed by the more important road materials.

Hardness is defined from the road makers' standpoint as "the resistance which a material offers to the displacement of its particles by friction. The measure of hardness will be, inversely, as the loss of the weight arising from the scouring by an abrasive agent."[2] This is determined by grinding specimens with sand of a standard size and quality.

By toughness is understood to mean the power possessed by a material to resist fracture under impact. It can be readily seen that toughness is an important property from the standpoint of the road builder.[3]

The cementing or binding power of a road material is the property possessed by rock dust, or other finely divided material found in nature, to act as a cement on the coarser fragments composing crushed stone or gravel roads. This property not only varies with different kinds of rocks, but also with those which are practically identical in classification and chemical composition. The impervious shell obtained by the use of a rock of high cementing value, gives the greatest protection to the foundation of a road. A good binding quality also lessens the amount of dust and mud. For further information on these important physical properties the reader is referred to the bulletin quoted above.

5. *Soils.*[4]

In our soil map the different types of soils have been shown as accurately as possible. Thus sandy soils are indicated by dots, and sand ridges by solid lines enclosed within such areas. Land composed of clay and clay loam have been felt unmarked. Muck land and its different varieties are indicated by symbols which are used to mark swamp land, which indeed it was originally. For further information concerning soil and sub-soil deposits, the reader is referred to chapter IV, and the map which has been prepared to accompany that chapter.

6. *Muck Land.*

In Bay county there are two principal types of this deposit; the first underlaid with clay, and the other with sand. Either type, if it be an acid muck, is not to be utilized unless properly treated. This treatment depends on the lack of conductivity of muck to heat and cold. While sandy soils show the frost extending down to a depth of four feet, a bed of muck was frozen to a depth of only eight inches. Therefore muck must be put on the ground in early winter, and scattered thinly over the ground surface in order to remove its acid properties. In Great Britain they resort to the process of "pairing and drying," cutting the surface into thin slices to dry it, and then burning the dried mass and scattering the ashes on the unburned portion.

"If swamp muck has sufficient drainage much of the potash, soda, lime, etc., will be carried off in the drainage water, and the ash of such muck will be proportionately poorer in these materials."

The addition of muck to clay lands makes them more open and friable. To get the best results, however, the system must be combined with thorough drainage. In light sands the addition of muck prevents excessive drying of the soil. It also absorbs and holds manure, and prevents its waste in the soil.

[1]Bull. U. S. Dep't of Agriculture, No. 79, p. 12.
[2]Id. p. 7.
[3]Id. p. 8.
[4]The U. S. Dept. of Agriculture has published a soil map of a portion of Bay county.

Dark colored substances absorb more sunlight than those of a light color. The following table will show the result of the addition of muck to clay and sand in increasing the temperature of the ground.

	Tile clay.	Tile clay+ 12% muck.	Gain.	Sand.	Sand+ 12% muck.	Gain.
May	59.57°	61.25°	1.68	59.57	60.89	1.32
June	70.79	72.02	1.23	70.89	73.21	2.32
July	81.75	83.07	1.32	82.07	86.72	4.65
August	70.59	72.32	1.73	71.25	73.26	2.01
September	57.25	59.22	1.97	58.59	59.72	1.13
Average gain	....	....	1.59	....	....	2.29

These observations are the result of readings taken at 7 A. M. and at 2 and 9 P. M., and extending from May 1st to October 1st.[1] The increased temperature given the soil has its obvious benefits in germinating and accelerating the growth of crops. Inasmuch as muck land has a greater development in this region than further south, the difference in latitude can in a measure be counterbalanced by the use of this material wherever it is available. Muck is also valuable on account of its power to absorb and retain ammonia. As Dr. Kedzie has remarked, it is a storehouse of fixed nitrogen and ammonia.

7. *Sandy Soils.*

This soil formation in Bay county is very often so thin as merely to aid in making the clay subsoil more tillable. The sandy and gravelly soils of Gibson township produce famous crops of potatoes, clover and hay. In other localities it produces fine crops of garden truck, it being a not uncommon sight in Bay and Saginaw counties to have a garden located on top of a sand ridge, and adjacent to the home where the drainage is good.

In Bulletin 198 of the Michigan Experiment station the cultivation of sand lucerene is advocated. This plant is allied to the alfalfa of the southwest, and is to be recommended on account of its adaptability to resist droughts. After the first year it will yield four crops of hay annually, the amount varying from 5,917 to 6,800 pounds to the acre at the State Agricultural College. I believe, however, that the sand and gravel soils of glacial origin there, may prove rather different than the lake sands of Bay county.

Amber cane has grown on sandy soil with greater or less success. While it is more capable of resisting drought than corn, the short season is rather against its complete development. The stalk is said to make very fair fodder.

8. *Clay Soils.*

The clay lands of Bay county do not need to call for any very extended notice here. In the cultivation of sugar beets it has been shown to be highly adapted. Oats, wheat, barley, corn and all the staple crops of this latitude

[1]R. C. Kedzie, Michigan Board of Agriculture, 1875, p. 224.

flourish abundantly when supplied with the proper amount of rainfall. Drainage, however, is essential and I trust that chapter V on Physical Geography and Drainage, along with the contour map showing the location of drains, drainage areas as yet undeveloped, and contour lines giving the approximate mean slope of elevation, will be of value in the intelligent development of the drainage system of Bay county.

9. *Water Supply.*

This subject naturally resolves itself into several points, i. e., the area and depth of flowing wells, the depth to ground waters which do not reach the surface, the variation in depth to salt water, and the water supply for Bay and West Bay Cities. With the subject of artesian water my purpose here is to indicate as accurately as possible the depth of such wells, and such information as I was able to obtain relative to the geology of the same. Also all information obtained concerning the time wells have been in operation, the present and earlier rate and strength of flow, the character of the water, temperature and amount of flow. These remarks also apply in part to non-flowing wells.

The area of flowing wells, together with the districts formerly supplied with such water supplies, is shown on the map prepared to accompany this chapter. The present and prospective areas of artesian water is indicated by heavy stippling; the former extent being shown by lighter shading.

It will be observed in general, that the area of artesian waters is adjacent to the low lands lying west of Saginaw bay, and in the valley of the two forks of the Kawkawlin river. An exception to this, however, is in the narrow belt of flowing wells in the central part of Pinconning township. The greater part of the artesian water is from the drift.

In the northeastern part of Williams township the depth of flowing wells varies from 80 to 95 feet. The wells are found in sections 1, 2, 3, and 12, near the south fork of the Kawkawlin river, and Skelton creeks. The water is slightly salty and comes from gravel beds in the drift. The altitude to which water will rise ranges from about 590 to 620 feet A. T. This area formerly extended up the valley of Culver creek to the southeastward at an elevation of from 585 to 605 feet A. T. Quite recently, Mr. Theodore Archambeau while drilling for coal in the valley of the south fork of the Kawkawlin river, obtained a flow near the north line of section 10, T. 14 N., R. 4 E. This is the northeasterly continuation of the former Culver creek area.

Northward from Williams and in Beaver township, the area of artesian water is in a general way contiguous to the basin of the two forks of the Kawkawlin river, and a heavy drift-filled pre-glacial channel which has a southwesterly course across Beaver township. Beds of gravel of pre-Wisconsin drift age, deposited within the limits of this old channel in the Coal Measures, furnish the conditions necessary for the origin of flows here. The source of water is probably from the north and west. Where such beds are tapped, as in this relatively low surface area, flowing wells are obtained. The elevation of this area of flowing wells in Beaver is from about 600 to 625 feet A. T., rising to the northward. There are at least two and probably three water horizons in Beaver township, the upper water bearing gravel being at a depth of from 60 to 80 feet, and a lower at 110 feet. The same wells occasionally obtain flows at about 65 and 110 feet. Still deeper wells in this drift valley region have obtained flows at depths varying from 173 to 197 feet. The amount of flow does not seem to bear any relation to the depth. Two of the heaviest flowing wells have depths as widely different as 93 and 173 feet, the former in the S. W. ¼ of section 35 and the latter the Cherry well in the S. E. ¼ of section 16 of Beaver township.

In Kawkawlin township artesian waters have been obtained in rather limited areas adjacent to the upper reaches of the north fork of the Kawkawlin river, the northeastern and southwestern portions of the township. This latter area formerly opened out to the east, including the lower reaches of the north fork, down to its junction with the south fork of the Kawkawlin in Monitor township.

The very limited area near the corner of sections 28, 29, 32, and 33, is in a swale traversed by Number One drain. The elevation is from 605 to 610 feet A. T. The depth here to water is 82 feet from the gravel bed on the rock. An artesian well in the rock is found in the S. W. ¼ of the N. E. ¼ of section 21. The depth of the well is 175 feet; elevation of surface about 605 feet A. T.

The absence of flowing wells from the drift in the southeastern part of Kawkawlin, the northern part of Bangor townships and adjacent to the bay, is explained by the upward rise of the bed rock in that direction, and the almost entire absence of gravel bearing beds in the drift there. The artesian water seems to come from the northwest, and was thus ponded back by the bed rock and impervious clay.

Northward in Fraser township, artesian conditions appear comparatively simple, flows being obtained in gravel bearing beds probably just overlying the rock. The wells are restricted to the area within two miles of the Bay, with a tributary area extending about three miles up Michie creek, and thence west northwest past Tebo P. O., up the valley of Chute creek, to the west line of Fraser township. In the valley of Michie creek flows were formerly obtained some five and a half miles west of the bay. The area adjacent to the bay is from 580 to 590 feet A. T. The westward continuation of this area, up the valleys of Michie and Chute creeks, is below the 620-foot contour line. The depth varies from 28 to 30 feet as in the northern portion of the township, to as much as 75 feet along the road from Linwood, following very nearly the inequalities of rock elevation. In the northwest ¼ of section 18, is a well from the bed rock 128 feet deep, which has ceased to flow.

In Pinconning township the Chute creek area of artesian water is extended northward through the central portion of the township, flowing wells being obtained at depths variously ranging from 45 to 85 feet, and from 600 to 610 feet A. T. Apparently the water is obtained from gravel beds overlying the rock, in a similar geological position to those to the southward. East of the Algonquin beach line, following the state road, flows have occasionally been tapped at depths varying from 38 to 60 feet, and extending from the lake level up to the 610-foot contour line.

In Mt. Forest township there is a small area of artesian water, which probably has a considerably greater extent. This is in the S. E. ¼ of section 10, elevation from 650 to 665 feet A. T., where coal drilling operations were carried on for John Mansfield. Flows were obtained there at 90 feet, at the base of the drift, and in beds of sand rock in the Coal Measures. Prospectively the best area to test in future development, would be to the north and west, in the basin of the Saganing.

Taking the artesian waters as a whole, it will be noticed that almost all flows are obtained from gravel beds very frequently at the base of the drift formation, or sometimes interstratified in the drift. Also that artesian water is often obtained in relatively depressed areas, and such areas are to a considerable extent determined by inequalities of the top of the bed rock, and the relatively low elevation of the gravel bearing beds in the drift formation.

While it is not possible to determine precisely the origin of the flows in the central and northern part of the county, it would not seem improbable that the elevated moraine covered with sand and gravel, traversing the western portion of Gibson township in a southwesterly direction, and thence southerly through Gladwin and Midland counties, furnish the catchment area. It is also thought that these beds of sand and gravel which hold the artesian water are interglacial, and were covered over by beds of hardpan and clay deposited during a later ice advance.[1]

Salt Waters. Depth to Brackish Water. Non-flowing Wells.

East of the Saginaw river the records of several wells in Hampton township show that water containing brine to a considerable extent, percolates upward in the Coal Measures to within about 125 feet of the surface. Above this depth, fresh water has been obtained at depths ranging from 30 to 80 feet.

In Merritt and Portsmouth townships, a number of well records indicate that wells in the drift having a depth of 80 feet, generally contain a small amount of saline matter. Shallow surface wells having a depth of from 15 to 20 feet, often contain an insufficient amount of water, beside being otherwise objectionable on account of the surface drainage, and organic matter which is apt to be washed in.

In section 14, Frankenlust township, a well obtained fresh water at a depth of 85 feet, but the same well after being extended to a depth of 130 feet became saline. For the central part of Frankenlust township the limit to which saline water percolates upward is about 100 feet. In general a fairly abundant water supply can be obtained at a depth of less than 50 feet.

The first shaft of the Pittsburg Coal Company near Amelith, struck a bed of water bearing sand at a depth of about 90 feet. The great quantity which was pumped out at that time affected the water supply over two miles away, as for instance the well at the Michigan House, which was pumped dry.

In Bangor township an abundant water supply of good quality is generally obtained at a depth of less than 30 feet. Fresh water is obtained down to a depth of 80 feet in section 19, but at 115 feet brackish water was obtained in the adjoining section. Apparently the upper limit of percolation of brines in Bangor is not far from that obtained in Frankenlust to the south. Westward in Monitor township, the depth to brine increases to about the same depth as was observed for Hampton township; i. e., 125 feet, although wells in the drift are occasionally slightly brackish at about 90 feet. There appears to be no difficulty in obtaining water at lesser depths. Wells here obtain their supply in sand and gravel beds overlying the rock. There is a tendency for the sand to work in and clog up the pumps, necessitating occasional use of the sand pump.

In Williams township numerous wells in the eastern half of the township, and including the area of flowing wells already described, obtain their supply from the drift down to a depth of 220 feet, the latter depth being reached

[1] F. Leverett, U. S. Geological Survey.

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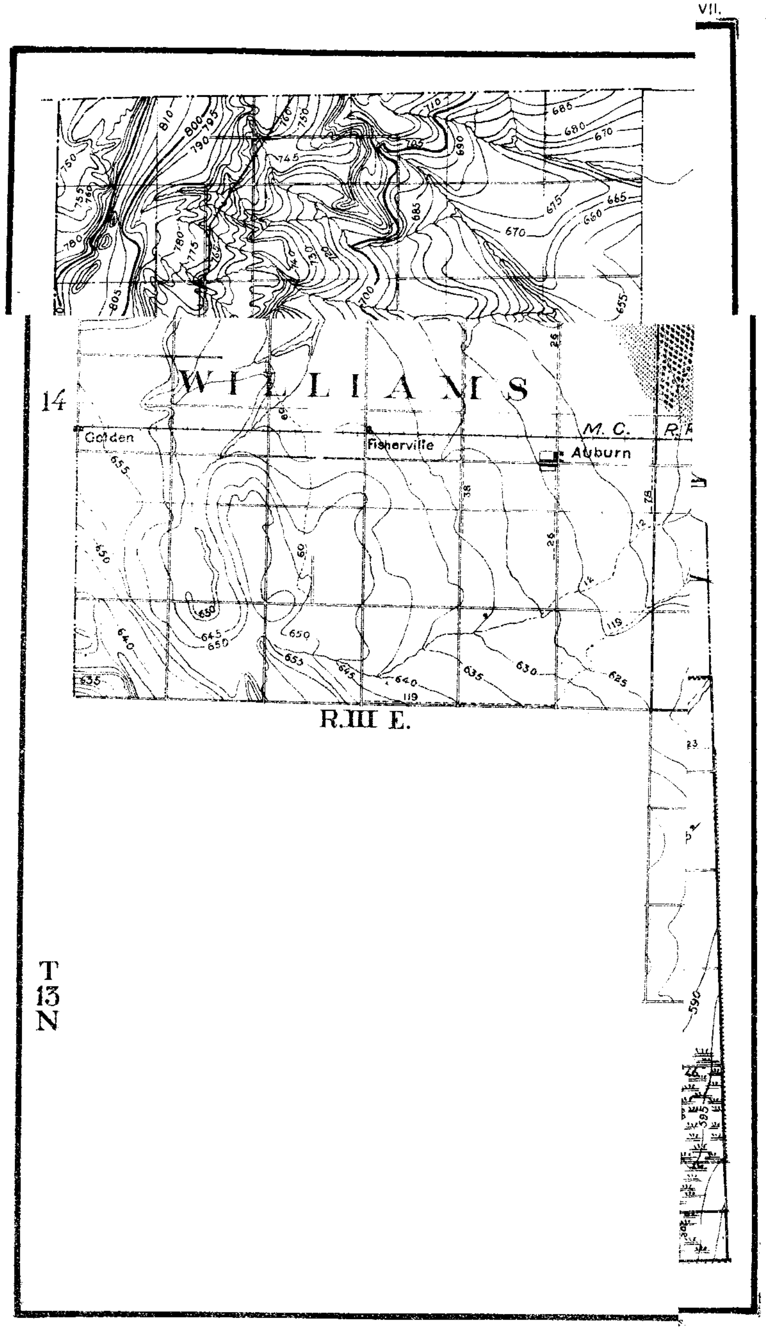

in the deep well at Auburn. There is at Auburn, beginning at the top, 80 feet of clay, 138 feet of sand, and 2 feet of gravel above the rock (which is a shale of the Coal Measures). The gravel is water-bearing, but the overlying sand acts as a sponge, through which the water circulates without collecting in sufficient quantities to furnish a stable water supply. The drift filled preglacial drainage valley over which Auburn is located trends east and west, increasing in depth westward. Along its course, it would be well wherever possible, to obtain water at a depth of less than 80 feet. The process of drilling through sand is difficult and expensive, beside the added difficulty of keeping the casing free from sand.

In Beaver and Kawkawlin townships, and outside of the area of flowing wells already described, a sufficient supply of water is generally obtainable at a depth of less than 90 feet. However, in the northwestern part of Beaver, a well went down 130 feet to obtain water from the drift. A well noted by Mr. Shaw in section 28 of Kawkawlin, yields brackish water from the rock at a depth of 160 feet. The same well found fresh water at 105 feet, and also in the rock.

In the tier of sections formed by Fraser and Garfield townships, there are, outside of the area of flowing wells described in Fraser, water supplies at a depth of less than 112 feet, as at Crump P. O., with the exception of an area in the southwestern portion of Fraser township. Wells which have been sunk here to a depth of 80 or 90 feet have become dry. This may be due to the subsurface drainage, though the cause for failure is still an open question. It is probable that supplies may be obtained by deepening the wells into the underlying bed rock, say to a depth of about 125 feet. Wells in the western part of Garfield are generally shallow, and should be deepened as fast as opportunity permits.

Wells in Pinconning township have usually been able to obtain a sufficient supply at depths of less than 80 feet, but are occasionally deeper. In the southeast quarter of section 9, a well 200 feet deep obtained a good supply of water without any objectionable mineral properties.

In Mt. Forest township the wells are generally shallow, with the exception of a few in the southeastern portion of the township. These have a depth of from 90 to 145 feet, a deep one being at the school house in section 13. These deep wells seem to be free from any objectionable mineral matter.

In Gibson township most of the wells are shallow, and should be deepened as rapidly as possible, in order to insure a permanent and pure supply. In the morainal region in the western part of the township, Mr. Enoch Harvey drilled 100 feet without obtaining a sufficient water supply. At Bently, however, Mr. Wm. Hinman obtained an abundant amount of good water in a sandstone formation of the Coal Measures, at a depth of 160 feet. In order to obtain a permanent supply in the morainal region in the western third of Gibson township, it will probably be necessary to go to a depth similar to that of the Bently well.

The Fluctuations of Wells.

No precise data were obtained concerning the actual amount of water running from flowing wells, nor of the capacity of non-flowing wells. Shallow wells show a tendency to either become greatly lowered in summer, or else completely dry up. The Cherry well located in section 16 of Beaver township, was put down about 1880, having a depth of 173 feet. The flow is constant and probably greater than that of any other flowing well in Bay county. The well of Wm. Peoples in section 32, of the same township, depth 74 feet, has ceased to flow.

Fraser township has a well 28 feet deep in section 2, put down in 1898, which had a steady flow in 1900. However, another well in section 6 of the same township has a ¼-inch stream which has decreased in volume. In section 28, a flowing well sunk in 1892, is now operated by a pump handle.

In Kawkawlin township a number of well records collected by Mr. W. T. Shaw, show a constant diminution in the volume of both flowing and non-flowing wells. In section 3, a well sunk in 1871 stopped flowing in 1884, and is now four feet from the top. Later in 1875, another well in section 34 with the water two feet from the top at that time, was considerably lower in 1900. A well sunk in section 8, in 1878, flowed for three years, and is now eight feet from the top. A well dug in 1884 in section 19 was somewhat lower in 1900. A well in section 34 was two feet below the surface in 1892, and six feet in 1900. A flowing well put down in 1894 in section 5, flowed one year. In 1900 it was nine feet below the surface. Likewise in the same year, another well in section 31, which then flowed two and a half feet above the top, now flows a small stream one foot above the surface. In 1895 a well in section 27 flowing one foot above the top, was in 1900, six feet below the surface. In section 32, still another well flowing a half inch stream one and a half feet above the top in 1896, ceased to flow in 1900. Another non-flowing well put down in the same section in the same year, was at that time six feet below the surface, is now much lower. In 1897 a flowing well in section 23, which then rose one and a half feet above the ground level, had ceased to flow in 1900. Another well put down in the same year in section 34, flowed one foot above the surface at that time; in 1900 the water level was 3.5 feet below the ground.

It is said that the first flowing well in Williams township was put down in section 4, in 1887. The flow was constant in 1900. The area of flowing wells in this township is rather limited.

Altogether the area of flowing wells, and the amount of flow may be said to be constantly diminishing. It would very likely be advisable to keep the water partially shut off when not in use.

Character of the Water.

The following notes are taken from the report of F. D. Owen on "Some Field and Laboratory Tests of Bay County Waters."[1]

"With reference to the applicability for boiler use, we note that the presence of calcium and magnesium carbonate and sulphate, oxides of iron and alumina and silica, constitute the encrusting solids, and that the presence of sodium chloride or brine in a water makes it very injurious to metal fittings as bolts, rivets, etc." Waters of this character were found in the drift at a depth varying from 55 to 113 feet, and in shaft No. 2 of the Bay County Coal Mining Co. at 150 feet. The deep Cherry well, however, already referred to, has none of these objectionable properties.

"According to the results, sodium sulphate and calcium sulphate or gypsum, may be said to occur most frequently in deep rock wells. Carbonate of lime appears to be most abundant in the deeper and rock wells. In the laboratory the waters often contained a considerable deposit of various salts and iron which had been in the form of carbonates, showing that a certain

[1]Report of the State Board of Geological Survey of Mich'gan for the year 1902, p. 10.

amount of carbonic anhydride had been present, but had been lost in transit to the laboratory."

"The hardness of the water shows it to be the greatest in drift, and least in deep rock wells, although in some cases the deep wells possess considerable hardness." Reference has already been made to the brackishness of the Bay county waters.

Herewith are presented the details of Floyd D. Owen's work in Bay county during the summer of 1902. Townships are arranged alphabetically, and under that numerically by sections.[1]

Beaver Township.

Section 2, Wm. Soper's mill. Driven well 66 feet deep in drift. Cl medium, Ca O, SO_4 O, CO_2 2, hardness 20 c.c.

Kawkawlin river, section 3, E. line. Surface water yellowish color, not colorless, but clear, river low and slow moving. Cl O, SO_4 O, Ca O, CO_2 O.

John Novak, section 15, east line. Driven flowing well 75 feet deep in drift. Ca trace, SO_4 O, Cl medium, CO_2 4, hardness 11 c.c.

Former Cherry well, section 16, E. line. Driven well, 173 feet deep in drift, fresh, soft, used for washing, iron in water. Ca O, SO_4 O, Cl medium, CO_2 3, hardness 6 c.c.

John Betzold, section 22, E. line. Well 16 feet deep in drift, bricked. Cl strong taste, SO_4 trace, Ca trace, CO_2 5, hardness 6.5, iron O.

John Endline, section 22, E. line. Driven flowing well 100 feet deep, 14 feet into rock, 8-9 years old, flow from drift (?). Ca low trace, Cl medium, SO_4 trace, CO_2 3, hardness 13 c.c., iron low.

Wm. Regenstein, section 26, W. line; 108 feet deep in drift, very salty, iron, big flow.

Celo Cessube, section 27, E. and S. line; 16 feet deep, dug, never dry. Also has driven flowing well, but prefers to use dug well. Flowing well 82 feet deep with some iron and salty. In dug well: Ca trace, SO_4 O, Cl medium, CO_2 4, hardness 7 c.c.

A. Emmet, section 35, W. line. Driven well 93 feet in drift, flowing 2-inch stream. Cl strong brine, Ca trace, SO_4 trace, CO_2 .3, hardness 10 c.c., iron quite strong.

Fraser Township.

M. Tebo, section 9, W. line. Driven flowing well 55 feet deep in drift, 11 years old. Cl trace, SO_4 trace, Ca trace, CO_2 4, hardness 7 c.c. iron low.

Wm. Hodder, section 22. Driven flowing well 45 feet deep, seven years old. Cl medium, Ca O, SO_4 O, CO_2 .3, hardness 15 c.c., iron trace plus.

Joseph Kerr, section 22. Flowing well 41 feet deep in drift, 12 years old. Cl medium, Ca trace, SO_4 O, CO_2 trace, hardness .9, iron trace.

Lengsville, section 26, center. Driven flowing well 45 feet deep in drift, Seven years old. Cl strong, salty, Ca trace, SO_4 trace, CO_2 .3, hardness 20 c.c., iron low.

H. Leavens, section 28. Driven well 85 feet deep, water within 3-4 feet

[1]Mr. Owen used a soap solution of such strength that one c. c. would be precipitated by 7-10 of a milligram of Ca CO_3.

To convert the hardness, figures herewith given into "degrees of hardness on Clark's scale," multiply the number of c. c. used by .49.

One degree on Clark's scale means one grain of Ca CO_3 in one gallon (70,000 grains) of the water. If the water runs less than 6 degrees it is usually considered fairly soft.

of the top, four years old. Cl low, SO_4 trace, Ca trace, CO_2 1 c.c., hardness 5 c.c., iron low.

Chas. Flood, section 30, S. W. corner; 190 feet deep, dug 1901. Cl low, SO_4 O, Ca O, CO_2 trace, hardness 19 c.c.

Wm. Clancey, section 33. Driven well 97 feet deep into rock, dug 1898. Cl medium, Ca O, SO_4 O, CO_2 trace, hardness 20.

J. S. Bouchard, section 34, S. line. Dug well 11 feet deep, dug in 1901. Cl, SO_4, Ca O, CO_2 .9.

Garfield Township.

Rogers (?), section 34, E. line. Driven well 112 feet deep in drift. Cl O, SO_4 medium to low, Ca low, CO_2 1 c.c., hardness 6 c.c., iron trace.

Kawkawlin Township.

Joseph Granger, section 2, S. line. Driven flowing well, 1897. Cl medium, Ca and SO_4 trace, CO_2 .5, hardness 8 c.c., iron medium.

Wm. E. Eker, section 2, N. E. corner; 70 feet deep into rock, flows. Cl medium, Ca trace, SO_4 trace +, CO_2 6, hardness 9 c.c.

D. B. Senay, section 3. Dug well 11 feet deep, dug 1890, rather soft, used for washing.

P. Lemieux, section 4, S. E. corner; 77 feet into rock. Cl medium, SO_4 trace, Ca trace, CO_2 trace, hardness 6 c.c.

Chas. Bevan. Driven well 78 feet deep into rock, formerly flowed. Cl medium, SO_4 trace, Ca trace, CO_2 .1, hardness 16 c.c.

Monitor Township.

Section 17, Wolverine Mine No. 2, water from 140 feet, Cl very strong, SO_4 O, Ca trace +.

Wm. Geiser, section 19, depth 14 feet in clay, never dry. SO_4 slight trace, Ca low, Cl medium, CO_2 2.5 c.c., hardness 4.5 c.c.

Pinconning Township.

Chas. Tremlien, section 11, N. line. Dug well 14 feet deep in drift, dug 1895.

Ernest Ruetz, section 21, S. W. part. Flowing well 52 feet deep, water from drift. Cl, SO_4, Ca trace, CO_2 .3, hardness 5.5.

L. Lapean, section 22. Driven flowing well 28 feet deep in drift, dug 1896. Cl low, SO_4 trace, Ca trace,— low, CO_2 2, hardness 5 c.c.

In Pinconning village, section 23, E. of hotel, depth 50 feet. Cl Ca, trace, SO_4 low, CO_2 .8, hardness 12 c.c.

School house, section 25. Driven flowing well. Cl strong, Ca low, SO_4 trace, CO_2 1 c.c., hardness 4.5 c.c., iron lots.

H. Schiminski, section 33, N. line. Driven flowing well, 75 feet deep into rock, used in boiler of creamery, and since December 5, 1900, has formed no more scale than an egg shell (written in summer of 1902). Cl trace, SO_4 low +, Ca and CO_2 trace, hardness 4 c.c.

Geo. Esseltine, section 33, W. line. Flowing well 56 feet deep, dug 1896, into rock. Cl trace, SO_4 medium, Ca trace, CO_2 1.1 c.c., hardness 6 c.c., iron low.

West Bay City.

State Street, just north of cemetery. Spring 11 feet deep (?), wood curbing, lots of water (probably at foot of Algonquin beach). Cl, Ca, SO_4 O, CO_2 1.2, hardness 14 c.c.

Williams Township.

S. Rowden, section 11, north line. Dug well 113 feet deep and 26 feet into rock, dug in 1892. Cl very strong, SO_4 O, Ca medium, CO_2 1.3, hardness 6 c.c., iron O.

G. A. Meyers, section 12, W. line. Flowing well 67 feet deep into drift, dug 1900. Cl strong, Ca O, SO_4, CO_2 trace, hardness 6 c.c., iron O.

B Phillips, section 14, W. line. Driven well 99 feet deep in drift, dug 1895, water seven feet from top. Ca low, SO_4 O, Cl medium +, iron none, CO_2 1.6, hardness 6.5 c.c.

Hotchkiss, section 15. Dug 98 feet in drift in 1898 or 1890, never dry. Ca trace, SO_4 trace, low, Cl strong, iron low +, CO_2 .3 c.c., hardness 6 c.c., water 7-8 feet from top in summer 1902.

Chas. White, section 22, E. line. Dug well 16 feet deep, 1889. Ca trace, SO_4 O, Cl medium, CO_2 1.3, hardness 12.5 c.c.

Kolb Bros, section 23, E. line. Drive well 217 feet deep in drift, drove in 1900. Ca, SO_4 O, Cl, trace, CO_2 .5 c.c., hardness 11 c.c., iron O.

Richard Turmelle, section 23, W. quarter post. Dug well nine feet deep in clay, dug 1901. Cl low +, SO_4 O, Ca very low, CO_2 1.1 c.c., hardness 5 c.c.

The following analyses are also taken from Mr. Owens' report:

	1.		2.		3.		4.		5.	
	Found 200 c.c.	Parts per 1000.	Found 200 c.c.	Parts per 1000.	Found 200 c.c.	Parts per 1000.	Found 200 c.c.	Parts per 1000.	Found 200 c.c.	Parts per 1000.
Total solids	2.380	11.90	.2534	1.2670	.1805	.9025	2.866	5.732	.375	.750
Total organic	.1965	.9825	.1014	.5070	.010	.050	.570	1.140	.135	.310
Total inorganic	2.1835	11.0175	.1520	.7600	.1705	.5825	2.296	4.592	.220	.440
Ca O	.0673	....	.0454	....	.01154	....	.01826	....	.00226	....
$Ca CO_3$	....	.4290	....	.37254	....	.01383	....	....	....	....
$Ca SO_4$	....	.20625	....	.04454	....	.10706	....	.08868	....	.01096
Al_2O_3, Fe_2O_3	.00806	.4030	.00876	....	.00176	.00880	.01286	.02572	.00086	.00172
MgO	.01394	....	.02263	....	.00386	....	.0005	$Mg SO_4$ .0030	.00053	$Mg SO_4$ .00318
$Mg CO_3$	....	.14635	....	.23767	....	.04053	....	....	....	....
$Si O_2$	.01106	.05530	.00706	.0353	.00326	.0083	.01386	.02772	.00906	.01812
Na Cl	2.00304	10.01152	.05148	.2574	.09009	.45045	2.19375	4.3875	.17555	.35110
SO_3	.0220	....	.00524	....	.01142	....	.0508	$Na_2 SO_4$ .08418	.01399	$Na_2 SO_4$ .03446

	6.		7.		8.		9.		10.	
	Found 500 c.c.	Parts per 1000.	Found 500 c.c.	Parts per 1000.	Found 500 c.c.	Parts per 1000.	Found 500 c.c.	Parts per 1000.	Found 500 c.c.	Parts per 1000.
Total solids	.147	.2834	7.230	14.460	.7020	1.4040	4.505	9.010	.6935	1.387
Total organic	.040	.080	4.195	8.390	.980	.1960	1.872	3.744	.1440	.2880
Total inorganic solids	.1017	.2034	.3035	6.070	.6040	1.2080	2.633	5.266	.5495	1.099
Ca O	.03443	....	.07718	....	.02768	....	.7595	....	.10785	....
Ca CO_3	....	.12296	....	.2696	....	.4170	....	.12954	....	.17258
Ca SO_4	....	....	....	.00822	....	.07772	....	.19258	....	.28093
Al_2O_3, Fe_2O_3	.00266	.00532	.00306	.00612	.00526	.01052	.00076	.00152	.00546	.01092
Mg O	.01031	....	.02847	....	.00702	....	.00234	....	.03472	....
Mg CO_3	....	.04330	....	.11956	....	.02948	....	.00822	....	.14502
Si O_2	.00586	.01172	.01736	.03472	.00426	.00852	.01156	.02312	.00566	.01132
Na Cl	.00731	.01462	2.9425	5.88510	.49725	.9945	2.56815	5.1363	.1638	.3276
SO_3	Trace.	....	.00242	....	.02286	....	.05658	....	.08501	....

Sample No. 1, Sam Rowden, N. Williams, 113 feet deep, pumped, rock well.

No. 2, Chas. White, 16 feet, clay, dug.
No. 3, Endline, 100 feet, clay, sand, gravel, rock, flowing.
No. 4, Meyer, 67 feet, gravel, flowing.
No. 5, Cherry, 180 feet, drift, flowing strong.
No. 6, Kawkawlin river, surface water.
No. 7, Bay Mine, 150 feet below, from coal, not used.
No. 8, Wolverine mine, bedrock water.
No. 9, Emmet or Lutz, clay, 93.5 feet, flow.
No. 10, M. Tebo, 55 feet, clay, clay and sand.

Water Temperatures.

The following observations were taken with an H. J. Green standard thermometer number 7529. In the shaft of the What Cheer Mine in section 30, T. 13 N., R. 6 E., the temperature of the water at a depth of 139 feet was 54.5°; at depths of 155 and 198 feet the temperature was 54°. In a shaft located one and a half miles east of Auburn, water pumped in large volume from a depth of 90 feet, was constant at 50° Fahr.

Mr. Lane obtained the following observations: At Pinconning a flowing well near the S. W. corner of section 27, depth 45 feet, had a temperature of 51.5°, June 14, 1900. Also at or near Riches bakery, Pinconning, a well 53 feet deep was 48.5°, August 6, 1901.

From August 12-26, 1904, the average temperature of Saginaw bay, near the shore of Saginaw bay, was 72.11°; during the night of August 22-23 and 25-26, 1904, 66.54°.

Water Supply for Bay and West Bay Cities.

Bay and West Bay Cities obtain their supply of water from Saginaw bay, like almost all the cities adjacent to the Great Lakes. This source of supply, even when obtained in cribs at a fair distance from the shore, is open to the objection of being polluted by drainage during periods of low water, or when the breeze is off shore, causing the river to flow north toward the intake pipes. It would also doubtless be advantageous to locate the intakes where the bottom is clay or sand, and free from organic matter.

A possible remedy for this may be found in the fine water obtained from the Marshall sandstone in Huron county. At Bad Axe the Coryell Drilling Co. is said to have drilled a well which produced 4,000,000 gallons every 24 hours. I do not imagine, however, that this will last unless carefully conserved.

Another project which has been discussed by Mr. E. L. Dunbar, Supt. of the Bay City Water Works Dept., involves the plan of obtaining water from the Tittabawassee river. Providing the quality was suitable, it would also be necessary to determine from the U. S. Government gage station at Freeland and Highwood, whether the amount was sufficient to supply future development. The elevation of the Michigan Central bridge over the Tittabawassee river at Highwood is 693 feet A. T. The top of the divide on the Midland road, and east of Midland City is very nearly 669.5 feet A. T., so that there is no insuperable engineering difficulty to overcome in order to bring the water to Bay City by gravity. However, probably the best solution to the question is to obtain water from the present source, removing contamination by filtration methods similar to those employed at Albany, N. Y. and Hamburg, Germany. Whether it would be advisable for the Bay and Saginaw cities to unite in a project of this sort, is a problem for the sanitary engineer to determine.

Since the above was written Mr. J. H. Tryon of West Bay City has given the Survey a sample of mine water containing 685 thousandths of one per cent. of sulphuric acid. This was from the abandoned entries of Wolverine No. 1 Mine near Wenona beach. The presence of sulphuric acid in the water is due to the oxidation of iron pyrites.

10. *Well Records.*

BANGOR TOWNSHIP.

Section 4.

Near the east quarter post. Goff Paul, driller. Salt water at 100 feet.

Cole. In the S. E. ¼ of the S. E. ¼. Dug well 22 feet deep, sand and muck for 6 feet, the rest being clay, never dry, 10 feet from top, in summer, hard.

Carter, in the N. E. ¼ of the S. W. ¼. Dug well 16 feet deep in clay, never dry, water 4 feet from top, hard.

Section 6.

In the N. E. ¼ of the N. E. ¼. Dug well 22 feet deep; 6 feet sand on the top, then clay; never dry, low in summer, hard.

Section 7.

Oeder. Coal hole 200 feet deep, 175 feet drift. Dug well 31 feet deep in clay, hard; never dry; water 4 feet from top in spring.

Section 8.

In the S. E. ¼ of the N. E. ¼. Dug well 22 feet deep, water 3 feet from top; hard, never dry.

Kayner. Dug well 14 feet deep in clay; hard, fresh; 4 feet from top, never dry.

Section 17.

Sage Land Company. Well at house 115 feet deep; rock at 100 feet with water which is hard and salty, 24 feet from top.

Another well 60 rods east,118 feet deep, rock 100 feet?, trifle salty, water 12 feet from top; wind from east, plenty of water; from S. W., W., N. W. not much.

Another well 160 rods east 200? feet deep, flow of water at 92 feet, fresh; rock at 90 feet.

Another well 20 rods southeast 180 feet deep, rock at 120 feet, no water.

Section 18.

Wilder, in the N. W. $\frac{1}{4}$ of the N. E. $\frac{1}{4}$. Dug well 16 feet deep, hard; surface water 4 feet from top in spring, never dry.

Section 19.

In the S· E. $\frac{1}{4}$ of the S. E. $\frac{1}{4}$. Dug well 20 feet deep in clay, water 6 feet from top, hard.
Emery. In the N· E. $\frac{1}{4}$ of the N. E. $\frac{1}{4}$. Drilled well 220 feet deep, 130 feet to rock, no sand below the clay, water 70-90 feet; 8 feet from top, hard, fresh.
Center. Rock at 117 feet, buried trees at 80 feet in clay, 4 feet thick, boulders in clay below.
G. A. Meed. Ninety-four feet to rock, clay to rock; water on top of sandrock.

Section 31.

A. S. Cody. In the S. E. $\frac{1}{4}$ of the N. E. $\frac{1}{4}$. Rock at 106 feet; 5 feet of marble (hard white sandstone) at 280 feet.

Section 32.

Bay shore and east 80-rod line. Seven feet white sand, then 19 feet clay, boulder of gypsum here.
In the N. W. $\frac{1}{4}$. Dug well 12 feet deep, 6 to 10 feet of sand, rest clay, never dry, hard, 3 feet from top.
Bay View foot of Henry St., 80 to 85 feet to rock, blue shale 30 feet, then sandstone to 130 for 25 feet + then 4 feet coal, then 3 feet fire clay. At 250 feet and 4 feet coal. West about the same.
Taylor, in the S. E. $\frac{1}{4}$ of the N. W. $\frac{1}{4}$. Rock at 45? feet.
East quarter post. Rock at 130 feet.

BEAVER TOWNSHIP.

Section 2.

Soper. Flowing well 112 feet deep, fresh; clay for 63 feet then hardpan for 20 feet, then gravel with water, medium hard.
Another well 63 feet deep in drift; $\frac{1}{2}$ medium flow, steady, fresh, medium hard.

Section 7.

Near the east quarter post, school house. Drilled well 150 feet deep. Water at 78 feet, fresh; 2 feet from top. Four feet coal, 138 feet from top.

Section 10.

Swiecicki. Flowing well, 84 feet deep in clay, small flow, fresh.

Section 15.

Schnett. Flowing well, 120 feet deep, good flow, fresh; all in drift, medium hard. Well drilled in 1897.
J. Novak. Flowing well 75 feet deep in drift, fresh, very fair flow.

Section 16.

Cherry. Flowing well 14 feet above ground, soft and fresh. Well down 10-12 years Well 173 feet deep, rock at 80 feet?, one flow at 103 feet, big flow at 173 feet.

Section 18.

Schlink, Dug well 9 feet deep, 5 feet of sand on top, rest clay; well dry in summer water soft at first, harder now.

Section 20.

Kraft. Flowing well 197 feet deep in drift, fresh, soft; flows 3 feet above surface, well put down in 1895.
Lindsay. Drilled well, 93 feet deep, clay for 80 feet, then rock—blue slate, water 4, feet from top, fairly soft, fresh.

Section 21.

Church—Lutheran. Drilled well, 126 feet deep, top 60 feet clay.
In another well 80 feet of quicksand below clay; water soft, fresh, 3 feet from top.
In the N. W. corner Kimel's store. Flowing well, 148 feet deep; full inch flow; 5 feet above top, 136 ? feet to rock, water soft, fresh.
Kimel. Flowing well 140 feet deep, water soft, fresh, fair flow; 4 feet above top.

Section 22.

Betzold. Flowing well 111 feet deep in drift, fresh, soft.
Bacon. Flowing well 187 feet deep, soft, fresh; one pail in six minutes.

Section 23.

Ederrer. Flowing well 73 feet deep; very fair flow in drift, fresh, soft.

Section 24.

Loehne. Eighty-seven feet deep in drift; soft, fair flow, not salty.
Another well, 136 feet in clay; soft, fresh, no flow.

Section 26.

Peltier. Flowing well.
In the N. W. $\frac{1}{4}$ of the N. W. $\frac{1}{4}$. Medium flowing well 85 feet deep, very little salty.

Section 27.

Walters. Small flowing well 85 feet deep, hard, very little salty.
Ittner Small flowing well 83 feet deep, all in clay, fresh, soft.

Section 29.

Horschig. Well 85 feet deep in clay, gravel and sand; water 6 feet from top in wet weather.

Section 31.

Herman. Dug well 14 feet deep; 7 feet sand on the top, rest clay. Water in gravel bed, never dry, 4 feet water now.

Section 32.

Peoples. Drilled well 74 feet deep; well used to flow, water 2 feet from top, all in drift; sand at the bottom, fresh, hard.
Livingston. Drilled well, 130 feet deep in drift, mostly blue clay, water in sand and gravel bed; water 15 feet from top, medium, hard, fresh.

Section 33.

Tonke. Flowing well 80 feet deep in drift, fresh, soft.

Section 34.

Wirsing. Drilled well 114 feet deep, rock at 70 ?. Water just to top, little salty, hard, probably from gravel over rock.
J. Sullivan. Drilled well 82 feet deep in drift; water 4 feet above, gravel, salty, hard.
Mueller. Flowing well 80 feet deep, fresh, all in drift.
Morrison. Flowing well 145 feet, rock at about 85 feet; flowing in gravel above rock, salty, hard, small flow.

Section 35.

Lutz. Strong flowing well, fresh, 93 feet deep in drift.

FRANKENLUST TOWNSHIP.

Section 1.

Engelhardt. Dug well 18 feet deep in clay, never dry; water 4 feet from top, soft, fresh.

Michigan House. Drilled well 106 feet deep; water at first 4 feet from top. Drained by Pittsburgh shaft near Amelith; trifle salty, rock at 90 feet.

Section 4.

In the S. W. part. J. M. Weiss. Rock at 147 feet, clay for 120 feet, then sand and gravel.

Section 5.

Lutz. In the S. E. ¼ of the S. E. ¼. Drilled well 104 feet deep. Clay to 104, sand below with water which is 28 feet from top, fresh and soft.
Behmlander. Dug well 20 feet deep in clay; water in spring 2 feet from top; sometimes dry in summer, hard.

Section 6.

Schlicker. Dug well 56 feet in drift, never dry.
Kasemeier. Dug well 20 feet deep; sometimes dry in summer.

Section 7.

Trautner. Dug well 18 feet deep in drift, never dry; water 10 feet from top, fresh and hard; water from west.

Section 8.

In the N. E. ¼ of the S. E. ¼. Dug well 18 feet deep in clay, never dry; water to top in spring.

Section 11.

Roth. Dug well 11 feet deep in clay. Sometimes dry in summer; water hard.

Section 12.

J. Neumeyer. Dug well 11 feet deep in clay. Dry sometimes in summer.

Section 14.

J. C. Neumeyer. Rock at 82 feet, 10 feet in rock; water is fresh, 5 feet from top; 10 feet sand on top, the rest being clay.
G. Neumeyer. Drilled well 130 feet deep, rock at 112-115 feet; 3-4 foot sand on the top, then drift; water at 85 feet up to 3 feet from top, fresh and hard; salty water at 130 feet or less.

Section 15.

J. A. Lutz. Drilled well 82 feet deep, sand 82 to 114 feet, rock at 114 feet; water here at 18–20 feet.

Section 16.

Redinger. Dug well 16 feet deep. Sometimes dry in summer.
Weggel. Dug well 20 feet deep in drift. Seldom dry, water 3 feet from top.

Section 17.

Wirth. Dug well 17 feet deep in drift. Seldom dry, water 3 feet from top, fresh and hard.
Haag. Dug well 18 feet deep in clay; never dry, water almost to the top, hard
In the S. E. part of the N. W. ¼ of the S. E. ¼. Rock at 137 feet, white sandstone at 225 feet.

Section 18.

G. Maurer. Dug well 22 feet deep; 4 feet black loam on the top, then reddish soil, the rest clay; water 10 feet from top in dry weather, never dry.
Ludgin. Dug well 18 feet deep in clay; plenty of water, hard.

FRASER TOWNSHIP.

Section 2.

In the N. E. ¼ of the S. E. ¼. O. Ouilettee. Flows steadily; put down in 1898; 28 feet to rock.

Section 4.

In the N. W. ¼ of the S. E. ¼. R. Williams. Flows 3 feet above surface a ½-inch stream; drilled in 1897; slightly mineral; 30 feet to sandstone.
In the S. ¼ post. Mary Coggins. Flows 2 feet above surface; 72 feet to rock.
In the S. E. ¼ of the N. W. ¼. J. P. Johnson. Forty-five feet to rock.
In the N. W. ¼ of the S. W. ¼. Dan Whyte. Flows ½-inch stream; slightly mineral; 28 feet deep.

Section 6.

In the N. E. ¼ of the S. E. ¼. F. Johnson. Flowing 2.5 feet above surface; ½-inch stream; put down in 1898; flow decreasing.
In the W. ½ of the N. W. ¼. Joseph LeFeure. Water to surface but not flowing; 70 feet to rock.

Section 7.

In the S. E. ¼ of the N. W. ¼. F. R. Wright. No flow; 60 feet to rock.

Section 8.

In the N. W. ¼ of the S. W. ¼. M. Coggins. Fifty-one feet to sandstone.

Section 9.

Near the W. ¼ post at Tebo's store and P. O. Flows ½-inch stream; slightly mineral; 50 feet deep, but not to rock.
Near the E. ¼ post. W. H. Curts. Water near the surface; 36 feet deep; not to rock.

Section 11.

In the N. ½ of the S. E. ¼. F. Davis. Flowing a one-inch stream; 2 feet high; slightly brackish; 60 feet to rock.
In the S. W. ¼. Michie P. O. Thirty-nine feet to rock.

Section 12.

In the N. E. ¼ of the S. W. ¼. E. Pommerville. Flowing a ½-inch stream; drilled 55 feet to rock.
In the N. W. ¼ of the N. W. ¼. J. W. Smith. Flows an inch stream; 2 feet above the surface; not salty; 40 feet deep.

Section 13.

In the N. W. ¼ of the N. W. ¼. Frank Oreonette. Flows a one-inch stream with force 18 inches high; strongest well seen yet; slightly mineral; 42 feet to rock.
In the S. E. ¼ of the S. W. ¼. Strong flow; 2 feet above ground; one-inch stream; not mineral; 48 feet deep.

Section 16.

In the N. W. ¼ of the S. W. ¼. Mill well. Water 6 feet below surface; 90 feet to rock.

Section 17.

In the W. ½ of the S. E. ¼. M. Jean. Dug 18 feet deep.

Section 18.

M. O. Bill. Water not brackish; not flowing; 55 feet to rock.
In the N. E. ¼ of the N. W. ¼. Flow has ceased; traces of iron; 128 feet to water; goes into rock.

Section 19.

In the E. ½ of the S. E. ¼. John Bastow. No water; 90 feet to rock.
In the S. W. ¼ of the S. W. ¼. Thos. Salmen. Not to rock; water 2 feet below surface, which is found at 85.

Section 20.

In the N. E. ¼ of the N. E. ¼. Wm. Hodder. Water mineral; 70 feet deep.

Section 22.

In the N. E. ¼ of the S. E. ¼. Jos. Kerr. Flowing a one-inch stream 3 feet high.
In the N. E. ¼ of the N. E. ¼. Wm. Hodder. Flows a 2-inch stream 2 feet high; slightly mineral; 45 feet deep.

Section 26.

In the S. W. ¼ of the S. E. ¼. Flowing one foot high; quite brackish; 48 feet to rock; said to have run a 2-inch stream at first; ¾-inch stream in 1900.
In the S. W. ¼ of the N. W. ¼. Water at 60 feet; drilled on for more to a depth of 109 feet; slightly mineral; ½-inch stream.
In the S. W. ¼ of the N. W. ¼. Flows a ¼-inch stream; 43 feet to rock.

Section 28.

In the E. ½ of the N. W. ¼. M. W. Glaspie. Water not mineral; 55 feet deep; drilled in 1892; flowed at first; pump now used.

Section 29.

In the N. W. ¼ of the N. E. ¼. John Bartholomew. Dug 10 feet deep.

Section 30.

In the W. ½ of the S. W. ¼. No water at all; 80 feet to rock; 4 feet into rock.

Section 32.

In the N. ½ of the S. E. ¼ of the N. E. ¼. J. Perrond. Sixty-two feet to rock; 30 feet in rock; water not good; black; says there is coal there.

Section 33.

In the E. ½ of the S. W. ¼. Wm. Clancy. Water to surface; lowers some in summer; 106 feet deep to hardpan.
In the W. ½ of the W. ½ of the S. W. ¼. J. Hertier. Flows ½-inch stream; slightly mineral; 75 feet deep.

Section 34.

In the N. E. ¼ of the N. E. ¼. Adolph Rivard. Total depth is 97 feet; 10 feet in rock; ¼-inch stream. Drilled by Mr. King of Linnwood in 1896.

Section 35.

In the N. W. ¼ of the S. W. ¼. Not much water; 80 feet to rock. Dug 12 feet and got plenty of water.
In the S. W. ¼ of the S. E. ¼. Fowlers. Water quite brackish; within 2 feet of surface; 60 feet to rock.

Section 36.

In the S. W. ¼ of the S. W. ¼. Flows ¼-inch stream 18 inches above surface; 60 feet to rock; brackish.
North of Linwood and on Bay shore bed rock at 50 feet steady?

GARFIELD TOWNSHIP.

Section 24.

In the S. E. ¼ of the S. E. ¼. E. W. Brown. One hundred thirty feet to rock; 5 feet in rock to water; water within 2 feet of surface; bed rock, first 50 feet of dry hole; 115 feet of sandstone; traces of coal.

Section 25.

In the S. W. ¼ of the S. E. ¼. Chas. Carey. Water 3 feet from surface; not mineral; 80 feet to rock.

Section 26.

In the S. W. ¼ of the S. W. ¼. Sawmill. Flowing a one-inch stream; not mineral; 112 feet to a bed of gravel; not to rock; (probably just to rock).

Section 28.

In the S. W. ¼ of the S. W. ¼. M. Schmidt. Dug well 12 feet deep.

Section 34.

In the N. E. ¼ of the N. E. ¼. Store. Practically the same as the well in the S. W. corner of Section 26, except that the water stands 5 feet below the surface.

Section 35.

In the S. W. ¼ of the S. W. ¼. A. T. Holcomb. Through 75 feet of clay and 25 feet of hardpan; 8 feet of sand; water within 5 feet of surface.

Gibson Well Records.

Section 1.

In the E. ½ of the E. ½ of the S. E. ¼. Winkel. Drilled 50 feet in the earth to bed of sand; flow; stream dried up.

Section 10.

In the N. E. ¼ of the S. W. ¼. Well 40 feet deep but not to water, thinks not to rock.

Section 12.

In the N. W. ¼ of the N. E. ¼. Walters. Dug 12 feet; 2 feet of water; nearly dry.

Section 20.

Wm. Hinman, Bently. Well 160 feet deep, clay for 115 feet to sandrock. Water from the rock within 32 feet of surface.

Section 29.

In the N. W. ¼ of the N. W. ¼. E. Harvey. Dug 20 feet and got water, then drilled 80 feet in clay to rock without getting more water. Pettit of Standish, driller.

HAMPTON TOWNSHIP.

Section 3.

Four-tenths of a mile east of the N. W. corner. Dug well 14 feet deep in clay, water 3 feet from top. Never dry, hard.

Section 8.

Near the center, ½ mile S. E. of Oak Grove hotel. Rock at 85 feet. At top sandrock, then shales, then 2 feet of coal at 125 feet, then gray shale, blue shale, and fire clay. Bottom soft white sandrock to 400 feet.

Section 13.

McDonald. Dug well 30 feet deep, never less than 12 feet of water. Mostly till, hard, fresh.

Section 15.

Woodbury. Drilled well 150 feet deep. Seventy-nine feet to rock, clay to rock, 4 feet 2 inches black shale—coal, then 2 feet of fire clay at 120-130. Rock below very hard, trifle salty, water at 127 feet below. Water varies from the top to 20 feet very suddenly. High at the time of the Galveston cyclone.

One-tenth of a mile S. of the E. ¼ post. Dug well 15 feet deep, 7 feet sand on the top; never dry, hard.

Section 17.

One-tenth of a mile N. of the S. E. corner. Drilled well 80 feet deep, least salty; water 5 feet from top; clay and gravel on top with shells.

Section 18.

Vink. Dug well 18 feet deep in clay. Dry in summer; sometimes hard.

Fisk. Dug well 13 feet deep in clay, hard, generally dry.

Section 19.

P. Wagner. Drilled well, bed rock at 80 feet, depth 108 feet, water fresh, 10 feet from top. Never dry.

Section 20.

One-half mile S. of the N. E. corner. Dug well 22 feet deep, hard water, never dry.

J. VanWort. Drilled well 120 feet deep, 80 feet to rock, fresh and dirty.

Section 21.

Remington. Dug well 80 feet in clay; water 60 feet from top now, fresh. Ten feet yellow clay—rest blue.

Section 25.

Engelhardt. Eighteen feet deep, water 2 feet from top, hard, never dry.

Section 26.

Near the S. ¼ post. Dug well 12 feet deep in clay, never dry.

Section 29.

Meyer. Drilled well at 85 feet deep, all in drift, plenty of fresh water at 85 feet. Water 16 feet from top.

On the S. line, .6 miles E. of the S. W. corner. Dug well 13 feet deep in clay, dry in summer.

Section 30.

VanSonieren. Drilled well 100 feet deep, 85 feet to rock. Water at 85 feet, 20 feet from top, fresh, never dry.

VanSonieren. Dug well 21 feet deep. Never dry in 3 years. Varies in level; full in spring.

Section 34.

Jos. Kraus. Dug well 20 feet in clay, never dry; water 4 feet from top.

Section 35.

In the S. W. ¼ of the N. E. ¼. Maxwell. Ninety-three feet to rock. At 176 feet salty water. Black shale at 125 feet.

Section 36.

In the N. E. ¼ of the N. E. ¼. About 85 feet to rock, water salty, not near the top.

KAWKAWLIN TOWNSHIP.

Section 2.

Allen. In the N. E. ¼ of the S. E. ¼. Flowing 18 inches high. One-fourth inch stream.

Bond. In the S. W. ¼ of the S. W. ¼. Seventy-six feet to rock, flowing; 67 feet through hard dry clay; 8 feet through putty clay.

Lutz. In the S. E. ¼ of the S. E. ¼. Seventy-four feet to rock.

Section 3.

In the N. W. ¼ of the N. E. ¼. Well east side of State road. Flowed at 70 feet on rock, then ceased to flow, and was drilled 50 feet into rock, water now at surface.

Senay. In the N. W. ¼ of the S. E. ¼. Seventy-five feet to layer of sand through clay, flowed at one time, now 2.5 feet from top.

Seeley & Parsons. In the N. W. ¼ of the N. E. ¼ west of the State road. Flowed when put down in 1871, 70 feet through clay and one foot to gravel, probably to rock surface. Cased with wood, bored with 6-inch auger. Water ceased to flow 6 years ago. Now 4 feet from top.

Section 4.

In the N. E. ¼ of the N. W. ¼. Chas. Beran. Dug well, 10 feet to water.

Lemieux, H. In the S. E. ¼ of the S. E. ¼. Drilled well 72 feet to rock through 66 feet of clay and 6 feet of sand, water 6 feet from top.

Section 5.

In the E. ½ of the N. W. ¼. Mary Wasser. Drilled 83 feet to rock by Lemieux of Kawkawlin township, water within 2 feet of surface, constant, said to get roilly before a storm.

In the N. ½ of the N. E. ¼. Katie Regan. Eighty-five feet to rock and 5 feet in the rock. Water quite soft and does not taste mineral. Stream small ½-inch stream.

Rivard. In the S. E. ¼ of the N. E. ¼. Seventy feet to rock, 31 feet in rock to water, through clay, water 9 inches from top, put down 18 months (1900))

Well on same place. Seventy feet to rock, flowed at first one year, put down in 1894.

Section 6.

Lacy. In the S. W. ¼ of the S. E. ¼. Dug well 18 feet deep, surface 2 feet sand and coal, the remaining distance is hard clay.

Section 7.

O'Connor's. Dug well 22 feet deep in clay, water 10 feet from top.

McGillis. In the S. E. ¼ of the N. E. ¼. Drilled well, rock at 80 feet, no water.

Section 8.

Jones. In the S. W. ¼ of the N. W. ¼. Drilled well, 85 feet to rock, water from gravel bed. Six feet from the top.

Swaffer. In the S. E. ¼ of the N. E. ¼. Well 87 feet to rock, 10 feet in rock, dry clay for 70 feet; flow at 87 feet, flowed about 3 years, put down 12 years, now about 8 feet from the top.

Section 11.

Devault. In the N. W. ¼ of the N. W. ¼. Seventy-six feet to rock; flowing.

Section 14.

Brisette. In the S. E. ¼ of the N. W. ¼. Seventy-six feet to rock, through clay to gravel on rock; pumped by wind mill.

Dubay. Seventy-six feet through clay to gravel on rock.

M. J. Sylvester. In the S. E. ¼ of the S. W. ¼. Eighty feet to flow. Flows a small stream which is stopped by pumping on well across the section line.

Section 15.

Wetters. In the S. W. ¼ of the S. W. ¼. Eighty-seven feet to rock, water 2.5 feet from top.

Section 16.

School house in the S. E. ¼ of the S. E. ¼. Eighty-seven feet to rock.

Section 17.

Oswald. In the N. W. ¼ of the S. W. ¼. Seventy-five feet deep; flowed 8 feet above surface. Located in flats of river below bank, water is soft.

Section 19.

Doty. In the N. E. ¼ of the S. E. ¼. Eighty-nine feet to gravel on rock; put down 6 years ago, has lowered some.

Section 21.

Beamlander. In the S. W. ¼ of the S. W. ¼. Seventy feet to rock, water brackish; 5 feet from top.

A. Hartley. In the E. ½ of the E. ½ of the S. W. ¼ of the N. E ¼. Total depth 175 feet, flows a small stream 6 feet above surface.

Section 23.

E. Peltier. In the N. E. ¼ of the N. W. ¼. Eighty feet to flow, put down in 1897; flowed 1.5 feet above the top, not flowing now, not brackish.

Schmidt. In the N. W. ¼ of the S. W. ¼. Dug well 14 feet deep, 6 feet of water.

Section 27.

Friebe. In the N. W. ¼ of the N. W. ¼. Eighty-four feet to gravel (above rock), water flowed one foot above surface at first, now 6 feet from top, put down in 1895, water brackish.

Dore. In the E. ½ of the S. W. ¼ of the S. E. ¼. Well 122 feet deep, 73 feet to rock, water 4 feet from top, has lowered some.

Section 28.

Purtell. In the N. W. ¼ of the N. E. ¼. Well 160 feet deep, very brackish. Second well 105 feet to sandstone, water not so brackish, not flowing.

Stremple. In the S. W. ¼ of the S. W. ¼. Seventy-six feet to gravel on rock, water one foot from top, never flowed; put down in 1893.

In the S. E. ¼ of the S. W. ¼. Blohm. Well 114 feet deep, 84 feet to rock through clay. In the S. W. part of the township, about 90 feet to rock. All wells through here are much the same; 2 layers of clay—first a hard red clay then 50 feet of softer blue clay.

In the S. E. ¼ of the S. E. ¼. O. J. Bedell. Eighty feet deep, water 6 feet from top.

Section 31.

Hembling. At the Northeast corner. Eighty-two feet in depth to gravel, flowed 2.5 feet above the surface in 1894; flowing a quarter of an inch stream now. One foot above the surface now.

Section 32.

Sprague, H. S. In the S. W. ¼ of the S. W. ¼; 80.5 feet through clay, 8 to 10 inches through shale, one foot into gray sandrock. Put down in 1896, then within 6 inches of the top, now much lower. Sprague, well driller.

L. Smith. In the E. ½ of the N. E. ¼ of the N. W. ¼. Eighty-four feet to gravel on rock. Water flowed one-half an inch stream 1.5 above surface in 1896, not flowing now.

Section 33.

Eighty rods east of the southwest corner. Eighty feet to gravel on top of rock.

Section 34.

Paig. In the N. ½ of the S. W. ¼ of the N. W. ¼. Ninety-two feet deep, put down in 1875; water 2 feet from the top at first, getting lower.

Graham. In the S. ½ of the S. W. ¼ of the N. W. ¼. Eighty-three feet to bed of gravel (above rock?) boulder 12 feet through 12 feet from the top, water 2 feet from the top in 1892, in 1900, 6 feet below.

Shultz. In the S. E. ¼ of the N. E. ¼. Sixty-five feet deep, flowed one foot above surface at first, now 3.5 feet from top, put down in 1897.

MERRITT TOWNSHIP.

Section 2.

Young. In the S. E. ¼ of the S. W. ¼. Rock at 99 feet, well 100 feet deep, clay to rock, salty water clear to top.

Section 3.

Grigg. One hundred twenty-seven feet deep, 90 feet to rock, clay to rock; salty water at 105. At school house ½ mile east fresh water 100 feet and bed rock at 80 to 85 feet.

Schlack. Dug well 18 feet deep, 2 feet sandy loam on top, then 3 to 4 inches of muck, then clay; never dry, hard.

Section 8.

Wyne. Dug well 10 feet deep, 3 feet of sand on the top, rest clay; water one foot below in spring, dry in summer.

Beyer. Dug well 14 feet deep, 2 feet of sand on top, the rest clay; never dry, full in spring, hard.

Section 11.

Leclair. Dug well 15 feet deep in clay, very low in summer, 13 feet below in spring, hard.

Section 12.

Martin. Drilled well 88 feet deep, not to rock, trifle salty; water 8 feet from top. Eighty to 90 feet to rock in this locality.

Section 15.

Ellison. Drilled well 83 feet deep in drift, trifle salty; water 4 feet from the top.

Section 20.

Munger. Dug well 20 feet deep, 1 to 7 feet of sand on top, rest clay. Water 8 feet from the top, hard.

Section 21.

Three-tenths of a mile east of the northwest corner. One foot of muck then till. Running water at 80 which comes 5 feet from the top, fresh.

Histed. Dug well 14 feet deep, 4 feet of sandy loam on the top, then hard clay all the way down; well dry in summer of 1900, hard.

Section 22.

North half. Drilled well 143 feet deep, rock at 80 feet, clay to rock, fire clay at about 100 feet, trifle salty, 2 feet from the top.

Section 24.

Wahrmann. Drilled well 111 feet deep, 80 feet to rock; trifle salty, clay to rock; water 1.5 feet from the top. Water at 180 to 200 feet. Too salty to use.

Section 25.

Hickey. Drilled well 90 feet deep, 89 feet to rock, 9 feet of sand and gravel above rock, clay for 80 feet.

Duby. Drilled well 70 feet deep in drift, salty; water 4 feet from the top. On the top sand beach east and west.

Section 26.

De Paemlaen. Dug well 16 feet deep, all in clay; dry in summer, hard.

Zumback. Drilled well 90 feet deep, rock at 80 feet; trifle salty, no quicksand.

Section 27.

In the N. E. ¼ of the S. E. ¼. Dug well 12 feet deep, 2 feet of muck on the top, rest clay, dry sometimes, surface water.

In the N. ½. Dug well 13 feet deep, 2 feet of muck on top, then one foot of sand, the rest clay, dry in summer.

Section 28.

Thayer. Dug well 14 feet deep in clay, never dry, hard; lots of water.

Section 30.

Blyth. Dug well 20 feet deep in clay. Dry sometimes, fed by surface water, hard.

Lynch. Drilled well 148 feet deep, rock at 85, trifle salty, water at 13 feet from top.

Section 32.

A. Sommerfield. Dug well, 11 feet deep, 2 feet of muck on top, clay below, never dry; lots of water at 6 to 7 feet where there is water bed, hard.

Osborne. Drilled well 158 feet deep, 90 feet casing to rock, salty, water 14 feet from the top.

Section 35.

D. Pommerville. Drilled well 129 feet deep, rock at 87 feet; water salty, never dry.

D. Pommerville. Dug well 16 feet deep, hard, never dry; low in summer.

Section 36.

French. Drilled well 95 feet deep, 4 feet of muck on the top, then clay. About 90 feet to rock, trifle salty; water 6 inches from the top.

MONITOR TOWNSHIP.

Section 1.

T. F. Marston. Dug well 20 feet deep at the foot of Algonquin beach; water is hard.

Section 2.

Fisher. Dug well 20 feet deep in clay, dry all summer, hard.

Section 4.

Beet. Drilled well 74 feet deep in drift-clay, never dry; water 4 feet from the top.

Schwarz. Drilled well 92 feet deep. Dry in summer of 1899.

Section 5.

Sitterding. Dug well 20 feet deep in drift, never dry; water 3 feet from the top, hard.

Section 7.

At the north ¼ post. Bed rock at 115 to 120 feet.

In the southeastern part. Rock at 115 feet.

Section 8.

Amsk. Dug well 12 feet deep, one foot sand on the top, the rest being clay; never dry, water 6 feet from the top, medium hard.

Sumner. Dug well 8 feet deep in clay, dry in summer; medium hard.

Periard. Drilled well 110 feet deep, 75 feet of clay, 33 feet of sand, then 2 feet of gravel probably above rock; water in gravel, hard and fresh.

Section 9.

Priem. Dug well 16 feet deep in clay; never clear dry, hard.

Section 10.

M. Arnold. Hard sandrock at 62 feet for 14 to 15 feet, then mixed shale and sandrock for 150 feet, then 3 feet yellowish or blue shale with 4 to 5 inches of coal, then 3 feet of fire clay, then 3 feet of sandstone, then 180 feet in hard white sandrock; 2.5 miles E. Auburn rock at 100 feet and 3 to 4 feet of coal at about 150 feet.

On the north line. Arnold. Drilled well 89 feet deep, 70 feet clay, then 17 feet of sand, rock at 90 feet; never dry; well used to flow, 3 feet below now, little salty.

Schneider. Drilled well 81 feet deep, never dry; water 2 feet from the top, fresh and hard.

Section 14.

Pajot. Dug well 14 feet in clay; never dry; 6 feet from the top, hard.

Section 15.

J. Lejewski. Drilled well 89 feet deep, sand at the bottom; never dry, water 6 feet from the top; trifle salty, magnesium.

At the west ¼ post. Rock at 90 feet.

Section 17.

Sloat. Drilled well 105 feet deep, some clay, then sand; water 3 feet from the top; medium hard.

Krzyzanick, A. Dug well 14 feet deep, sand on the top, then clay; never clear dry, hard.

Section 18.

In the S. E. corner. Rock at 95 feet. At 10 to 12 feet down to 4 feet of sand.

In the southwestern corner. Rock over 173 feet. At 173 feet flow to top for several years. Sand for 70 feet at the bottom.

Section 19.

In the west ¼ post. Rock at 130 feet, 44 feet sand above the rock.

Section 20.

J. Grobe. Drilled well 64 feet deep in drift; never dry, well used to flow 8 feet above the ground, now 3 feet from the top, fresh.

Nesbit. Drilled well 64 feet deep; well used to flow, now 10 feet from surface.

F. Shaw. Rock at 90 feet, 3 feet of coal at 130 feet.

Wm. Shaw. Four feet of coal at 140 feet.

Section 22.

E. Young. Drilled well 82 feet deep, seldom dry, mineral; slightly salty.

Gaffney. Drilled well 157 feet deep, salty.

Another well 123 feet deep with fresh water.

Section 23.

Adams. Drilled well 110 feet deep, rock at 107 feet; 8 feet of sand above rock; plenty of water, fresh; 12 feet from the top.

Section 24.

Kroener. Drilled well 154 feet deep, rock at 85 feet; never dry; fresh water at 60 feet, salty at 154 feet.

J. L. R. Drilled well 88 feet deep, clay and sand, just to rock. Water fresh, used to be level with surface, now 10 feet from the top.

J. L. R. Clay 88 feet, sand to 130 feet, rock 50 feet black shale. Water on the top of rock.

Section 25.

At the Air Shaft of the Central Mine (Knapps). Seventy feet of clay, then 18 inches of hardpan, then into sand, gravel and boulders. One boulder 4.5 feet long, 2.5 feet wide, 22 inches thick, then bed rock.

One-half of a mile west of the Michigan mine. One hundred twenty-two feet to rock.

Section 26.

In the N. W. ¼ of the S. E. ¼. Rock at 80 feet.

Section 27.

Schnell. Dug well 12 feet deep, 5 feet of sand on top, rest clay; well never dry, hard.

Section 28.

Willcox. Drilled well 197 feet, 65 feet of clay on the top, 96 feet to bed rock, 14 inches of coal at 136 to 140 feet; water 45 feet from the top having dropped 9 feet since the well was drilled; water cathartic. About 60-70 rods away plenty of fresh water at 10 feet; fresh.

Section 29.

Feinaur. Drilled well 60 feet deep, some sand below 40 feet; never dry, in spring water is 4 feet from the top, hard and fresh.

Section 30.

J. Zill. Drilled well 117 feet deep, 57 feet of clay, 60 feet of sand, then gravel; never dry; water 12 feet from the top, fresh.

Gavin. Dug well 20 feet in clay; well sometimes dry; in spring the water is up to the surface and is hard.

Section 31.

Felker. Drilled well 65 feet in drift, seldom dry; 5 to 6 feet high in spring.

Helmreich. Drilled well about 130 feet deep; salty water, stopped in sand.

Section 33.

Leinberger. Drilled well 82 feet deep, sand and gravel at the bottom with water; never dry; water used to come 4 feet from the top, lower now.

About one-half of a mile northeast of the southwestern corner. Fifty feet of clay, quicksand for 40 feet, then rock.

In the southwestern part. Eighty feet of clay and no sand; water at about 80 feet.

Section 35.

Deneke. Drilled well 175 feet deep, about 80 feet of clay, 40 to 50 feet of sand; no rock; water 6 feet from the top.

Sturm. Drilled well 90 feet deep; plenty of water.

Center of the N. W. ¼. One hundred seventy-five feet to rock

MT. FOREST TOWNSHIP.

Section 10.

In the S. E. ¼. J. Mansfield. Rock at 92 feet. One flow of water at rock, then by drilling in rock 170 feet got a second and stronger flow. Out of eight holes, five flowed. (See chapter on coal for record of holes).

Section 13.

School house in the S. W. corner. Eighty feet to rock and 145 feet in all; water very constant, 12 feet from the top, no flowing wells near here.

Section 22.

Hudson. In the S. W. ¼ of the S. W. ¼. Dug well 16 feet deep.

Section 23.

J. Hooker. In the S. E. ¼ of the S. W. ¼. Dug 17½ feet and drilled 90 feet to gravel (above rock), water within 12 feet of the top.

Wasielewski. In the N. E. ¼ of the N. E. ¼. No water in his wells, one went 83 feet to rock, and the other to 90 feet. Mt. Forest bed rock at 90 feet. The average depth to rock in Mt. Forest is 87 feet. (?)

Section 26.

Lalonde. In the S. W. ¼ of the S. E. ¼. Dug well 12 feet to water.

Eighty rods east of the S. W. corner. Wilson. Drilled well 107 feet to rock, water 3 feet from the top.

Section 33.

Warren. In the N. E. ¼ of the N. E. ¼. Dug well 10 feet deep, 2 feet of water.

Section 36.

Derren. In the N. W. ¼ of the N. E. ¼. Dug well in clay, 12 feet deep, 6 feet of water.

PINCONNING TOWNSHIP.

Section 1.

A. Valley. In the middle ⅓ of the W. ½ of the N. E. ¼. Dug 10 feet deep, water near the surface.

Section 3.

G. Stephenson. In the E. ½ of the N. E. ¼. Drilled 35 feet to rock, rose within 5 feet of the top.

Section 4.

In the N. E. ¼. Dug 13 feet in clay, water 6 feet from the top, abundant.

Section 9.

E. Breman. In the S. W. ¼ of the S. E. ¼. Drilled 200 feet deep, no flow; good supply, not mineral.

Section 11.

M. E. B. In the S. ½ of the N. E. ¼ of the S. E. ¼. Dug 15 feet deep, 6 feet of water.

Section 13.

C. Peters. On the E. and W. line (¼) 80 rods W. of the E. ¼ post. Well is brackish, one-half inch stream, 2 feet from top, traces of iron.

Section 14.

Brown & Jennings. In the W. ½ of the S. E. ¼ of the S. W. ¼. Well 50 feet to gravel (above rock?), one-half inch stream, slightly mineral.

Section 15.

B. Stewart. In the S. ½ of the S. E. ¼ of the N. E. ¼; 61 feet to rock 1½ feet in rock, flowed 1.5 feet from the top, not flowing now.

Section 16.

Dolph. In the S. E. ¼ of the N. E. ¼. Drilled 65 feet to rock, cased 10 feet; fresh water flowing steadily.

Legness. In the N. W. ¼ of the N. W. ¼. Dug well 12 feet deep, goes dry.

Tatro, N. In the S. E. ¼ of the S. W. ¼. White sandrock at 65 feet, clay to rock, no flow.

Section 17.

P. Bodrie. In the W. ½ of the S. E. ¼ of the S. W. ¼. Dug well 16½ feet deep, 9 feet of water; went dry one season, good water.

Section 18.

On the E. and W. ¼ line 1-10 of a mile W. of the shore line. Drilled well 50 feet deep, ¼ of an inch stream; rising 3 feet below the top; very salty, traces of iron.

Section 19.

H. Lowe. In the N. ½ of the N. E. ¼ of the S. E. ¼. Seventy-three feet on rock, water 3 feet from the top; clay all the way down.

Section 21.

E. Rentz. In the S. E. ¼ of the S. W. ¼. Dug well 13 feet deep, 7 feet of water.

Section 22.

McLean. In the S. W. ¼ of the N. W. ¼. Drilled well one-fourth of an inch stream, 2.5 inches above the top; slightly mineral.

Section 24.

School house 80 rods west of the S. E. corner. Flowing well, water salty; traces of iron, runs one-half inch stream, flows 2 feet above the surface.
N. Lee. In the S. E. ¼ of the S. E. ¼. Thirty-three feet deep, not to rock; salty, flows one-half inch stream 2 feet above top of well.
S. R. Ballard. Eighty rods N. and 80 rods W. of the S. E. corner. Thirty-eight feet to rock, one inch stream; 2 feet above top, drilled in fall of 1898; salty.
Also dug well 14 feet deep, water fresh; varies from 2 feet in summer to 12 feet in spring.

Section 25.

J. H. Plummer. Eighty rods east of the S. W. corner. Forty feet to rock, 60 feet to water; at 209 feet found 3 feet of coal; flows one-half an inch stream 2 feet high, salt, shows iron.

Section 26.

Near the north quarter post. Porter's. Drilled well 60 feet deep, not to rock; flows 2 feet above, runs one-half inch stream; said to flow 6 feet above, brackish.

Section 27.

D. Dalke. At the S. W. corner. Drilled well 45 feet deep; 3 feet above top—flowing. Eighty rods S. of the N. E. corner. Dug well 25 feet deep, at first 21 feet of water, in 1900, 20 feet.

Section 29.

O. Newman. In the S. E. ¼ of the S. E. ¼. Drilled well spring of 1900. Forty-eight feet deep. Does not flow.

Section 30.

H. A. Mosher. In the S. E. ¼ of the S. E. ¼. Drilled well 85 feet, not to rock; water 1 foot above the surface.

Section 32.

H. Messner. In the N. W. ¼ of the N. E. ¼. Drilled well 47 feet deep in fall of 1899. Water flows over the surface.
G. Schinijuski. In the N. E. ¼ of the N. W. ¼. Drilled well 60 feet deep but not to rock, water just to the surface.
F. Allor. In the N. E. ¼ of the S. E. ¼. Drilled well 45 feet to the water; flows 2 feet above the top of the well.
In the S. E. ¼ of the S. E. ¼. P. O'Keefe. Drilled 56 feet to rock. Sand on rock.

Section 33.

J. Eseltine. In the W. ½ of the S. W. ¼. Fifty-six feet to the rock, flows 2 feet above the top; drilled in 1897.

PORTSMOUTH TOWNSHIP.

Section 1.

Walther. Dug well 16 feet in clay; water 3 feet from the top, never dry, hard.

Section 2.

Chatfields. Rock at 125 feet.

Section 3.

Henry. Dug well, 28 feet deep; never dry; 3 feet from the top, hard.

Section 4.

Cartwright. Dug well 10 feet deep; 3 feet of sand on top, rest clay; never dry, water irony, hard.

Section 5.

Lindner. Dug well 25 feet from the top; never dry, water 2 to 4 feet from the top, hard.
Bublitz. Well 109 feet deep; slightly salty, water 10 feet from the top, never dry; little flow.

Section 6.

Decorte. Dug well 20 feet deep in clay; water 2 to 20 feet down, hard.
Young. Dug well 196 feet deep, 100 feet to rock, clay to rock; salty, water 8 feet from the top, small flow, never dry.

Section 7.

Brandt. Drilled well 135 feet deep, 90 feet to rock; water 5 feet from the top, water fresh, hydrogen sulphide.
Wagner. Dug well 18 feet in clay; water 7 to 8 feet from the top, hard, never dry.
Wilkins. Dug well 20 feet deep in clay; water low in summer; sometimes dry, hard.

Section 10.

Matts. Dug well 16 feet deep. Water to the top in spring, never dry.
Another well 12 feet deep with lots of water always.
On the north line and in the N. W. ¼; 105 feet to rock.

Section 11.

Howard. Dug well 19 feet deep; water 4 feet from the top, never dry, hard.
Gates. Rock at 125 to 130 feet, fresh water at 240 feet.
Gates. Drilled well 241 feet deep; salty, water to the top.

Section 12.

Boes. Dug 65 feet in clay, 10 feet in dry gravel, then 18 feet in sand, then into hard-pan.

Section 13.

Seebeck. Dug well 14 feet deep. Plenty of water 4 feet from the top.

Section 31.

Timm. Drilled well 157 feet deep; rock at 90 feet; salty water 9 feet from the top, never dry.
On the north line, ¼ mile E. of the N. W. corner. Dug well 15 feet deep in clay; water 1 to 2 feet from the top, hard.

Section 32.

Koester. Drilled well 251 feet deep; fresh water, 10 feet from the top; rock at 80 feet.

Section 33.

Young. Dug well 6 feet deep in clay; never dry.
Underwood. Dug well 124 feet deep, 90 feet to rock, clay to rock; water 4 feet from the top; hard, salt, never dry.

Section 36.

Wanderwilt. Drilled well 153 feet deep, 91 feet to rock; very little salt; water 6 feet from the top, never dry.

WILLIAMS TOWNSHIP.

2.5 miles N. Auburn rock at 93 feet.
1.75 miles S. Auburn rock at 130 feet.
One mile N. Auburn rock at 124 feet.

Section 2.

Hutchinson. Flowing well 75 feet deep, salty; 4 feet of sandy loam on the top, hardpan the rest of the way; 3 feet of sand and gravel at the bottom with flow, hard.
Sullivan. Flowing well 84 feet deep in drift; small flow, hard; little salty.

Section 3.

Burk. Flowing well 85 feet deep in drift, hard, salty.
Abard. Water 4 feet from the top; 90 feet deep, least salty, hard.

Section 4.

In the east part, Hardy. Put down first flowing well in 1887. Depth 93.5 feet, salty; all in drift, clay and hardpan for 71 feet; then 20 feet of fine sand, then 2.5 feet of gravel, which probably rests on rock.
Shurkey. Drilled well 83 feet deep in drift, little salty, hard, drift coal.

Section 5.

Gates. Dug well 26 feet deep in clay; well almost full, never dry, hard.
Forster. Drilled well 72 feet in drift; water 9 feet from the top, never dry, least salty, hard.

Section 7.

Dingman. Dug well 11 feet deep, sand on top, rest clay, hard, never dry.

Section 8.

Arthur. Drilled well 110 feet deep in drift; gravel at 80 feet, clay and hardpan below, then coarse sand with water; water 18 feet from the top, fresh, medium hard.
Near the southeast corner. Kohler. Clay for 90 feet, sand and gravel 30 feet; water at 120 feet, 8 feet from the top, fresh and soft.

Section 9.

J. B. Plant. Drilled well 100 feet deep; water 3 feet from the top, brackish; rock at 85 to 90 feet.
Wm. Plant. Drilled well 23 feet deep; never dry, soft and fresh; all in clay.
Emanof. Drilled well 100 feet deep in drift, water soft, fresh; 8 feet from the top.
Kohler. Drilled well 125 feet deep; 100 feet to rock; water 10 feet from the top, fresh and hard, softer than surface well.

Section 10.

Hopler. Drilled well 90 feet deep in clay, red clay at the bottom. Water 6 feet from the top; hard, very little salty.
Buzzard. Drilled well 82 feet deep, rock at 60 feet—boulder. Water salty, gravel at the bottom, flows 1 foot above the top, hard. In coal hole rock at 100 feet. Vein of coal 18 inches at 165.
At the N. E. corner. Drilled well 74 feet deep in drift; water 4 feet from the top.
Another well 84 feet deep in clay, sand at the bottom; water 6 feet from the top.
Richardson. Drilled well 122 feet deep in drift; 4 feet of sand at 72 feet, clay below; salty water at 120 feet.
Van DePlas. Dug well 25 feet deep in drift, water hard.

Section 11.

Kennell. Flowing well 60 feet deep, salty.
Meyers. Flowing well 68 feet deep, clay down to gravel; flow in gravel, salty. Drilled well 116 feet deep, water almost to top, salty, all in drift.
S. Rowden. Drilled well at 113 feet; rock at 86 feet, water at 80 feet in sand and gravel. Then flow of water to the top at 113 feet.
Pfund. Dug well 17 feet deep in blue clay, dry.

Section 12.

Beattie. Drilled well 112 feet deep, salty, hard; used to flow, clogs with sand.
Carlson. Dug well 14 feet deep in clay, fresh and never dry.

Section 13.

Gartung. Drilled well 67 feet deep in blue clay; water 5 feet from the top; slightly salt, water from sand and gravel bed in the bottom.
On the east line. Rock at 125 feet, clay for 120 feet; water on the top of the rock in sand and gravel; shale on top, coal at 135 feet and 160 feet.

Section 14.

Phillips. Drilled well 99 feet in drift; fresh, hard, 7 feet from the top.

Section 15.

Horn. Dug well 12 feet deep in clay and gravel, hard, sometimes dry in summer.
Well at Auburn near the depot. Clay 80 feet, sand 138 feet with drift coal, then 2 feet of gravel with water; little salty and hard; blue shale at 220 feet.
Hotchkiss. Drilled well 112 feet deep in clay and gravel. Water salty, at first 9 feet from the top, farther now.

Section 16.

C. Kindell. Dug well 16 feet deep in clay; dry in August, hard and fresh.

Section 17.

Kraus. Dug well 18 feet deep in drift; dry in summer of 1899; soft.
Twenty-six chains south of the northwest corner. Dug well 10 feet deep almost all in sand; soft water, never dry.

Section 18.

J. B. Mathews. Dug well 14 feet all in clay and gravel, hard and fresh.

Section 19.

Berger. Dug well 16 feet deep, sand and clay below. Never dry, hard.

Section 22.

White. Dug well 22 feet deep. Never dry, hard.

Section 23.

Kent. Drilled well 60 feet deep in drift; water 7 feet from the top, hard and fresh.
Keher. Dug well 17 feet deep in clay (sandy), dry in summer of 1899. Hard and soft.

Section 24.

O. Rosekrans. Drilled well 82 feet deep, sand in the bottom, fresh and hard.

Section 25.

In the eastern part. O'Connor. Dug well in clay, 13 feet deep, hard, never dry.
Cagwin. Drilled well 85 feet deep in drift; water 7 feet from the top, hard and fresh.
Hemmingway. Drilled well 125 feet deep in drift; water hard, fresh, 8 feet from the top.

Section 26.

Swartz. Drilled well 122 feet deep in drift; lots of water, fresh and hard.

Section 27.

Eddy. Dug well 12 feet deep, 4 feet in sand on surface, rest clay; never dry; 6 feet from the top in summer of 1900.

Section 28.

In the S. ½ of the S. E. ¼. One hundred eighty-seven feet to rock, 175 feet clay and sand below.

Section 32.

Fischer. Dug well 10 feet deep in sand and clay. Well dry in summer, hard.

Section 33.

Dalrymple. Dug well 12 feet deep in clay; hard, never dry; 6 feet of water in the well.

Section 34.

Bierd. Drilled well 143 feet deep, 80 feet of clay on the top; water 30 feet from the top; hard and fresh.

Section 36.

Terry. Drilled well 59 feet deep, clay for 52 feet, 7 feet of gravel at the bottom; water 7 feet from the top, soft, never dry, stationary.