Natural Science Report, Ochanomizu University, Vol. 15, No. 2, 1964
お茶の水女子大学 自然科学報告 第15巻 第2号

# The Wells in the Central Section of the Nasuno-Basin— A Problem of the Regional Division (2)

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(*Received September 10, 1964*)

In *the preceding paper the wells in the central section of the Nasuno-basin were studied from the regional point of view, especially in connection with their depth, the depth of the water table and the thickness of the water, mainly on the basis of the field observation which was practised by the Ministry of Agriculture and Forestry on Oct. 1, 1950. Hereafter this preceding paper is called paper (1).

As for the depth of the wells as well as the depth of the water table, new field surveys were carried out by the Kantô Regional Office (Kantô Nôsei-Kyoku) of the same Ministry three times in 1963, i. e. through May 6–8, on Jul. 23 and on Sept. 2, for a group of 117 selected wells which are situated in the central section of the Nasuno-basin. The results were published in "The Report on the Surveys in the Nasuno-ga-hara, 1963" (Jap.). In the present paper these three observations are analysed from the same regional view point as in paper (1).

For this purpose the coordinate, on which the $x$- and the $y$-axes represent respectively the depth of the wells and the depth of the water table and which was used in paper (1) as an effective technical tool, is also put in use in the present paper. As for the graphic representation of the thickness of the water, the $z$-axis on this coordinate, which passes through the original point and inclines at an angle of 45 degrees to the $x$- and the $y$-axes respectively, plays an essential role as was minutely illustrated in paper (1).

The wells are represented on this coordinate, according to their depth and the depth of the water table, for each one of the three surveys of 1963, in exactly the same way as in paper (1). As for the relationship between $x$ and $y$, or between the depth of the wells and the depth of the water table, the same tendency which was recognized in paper (1) is also noticed evidently for the respective observations

* Matsui, I.: The Wells in the Central Section of the Nasuno-Basin—A Problem of the Regional Division. Natural Science Report, Ochanomizu University, 15 (1964), 41–52.

of 1963, i.e. the depth of the water table increases, as a general rule, keeping pace with the depth of the wells. This rule was expressed by the function $y=x-c$ in paper (1), where the thickness of the water which was represented by $c$, ranged within certain upper and lower limits which were characteristic of the six regional groups of the wells being separated on the coordinate by reference to their areal distribution.

These groups were illustrated on the same coordinate by six polygons, which were confined by five or six lines running parallel to the $x$-, the $y$- and the $z$-axes respectively. These lines represent those limiting values regarding the depth of the wells, the depth of the water table and the thickness of the water which are characteristic of each individual group. On the basis of those limiting values, six subsections A, B, C, D, E and F were established in the central section of the basin, which correspond to the six groups on the coordinate. In the following discussions these six subsections are called the former

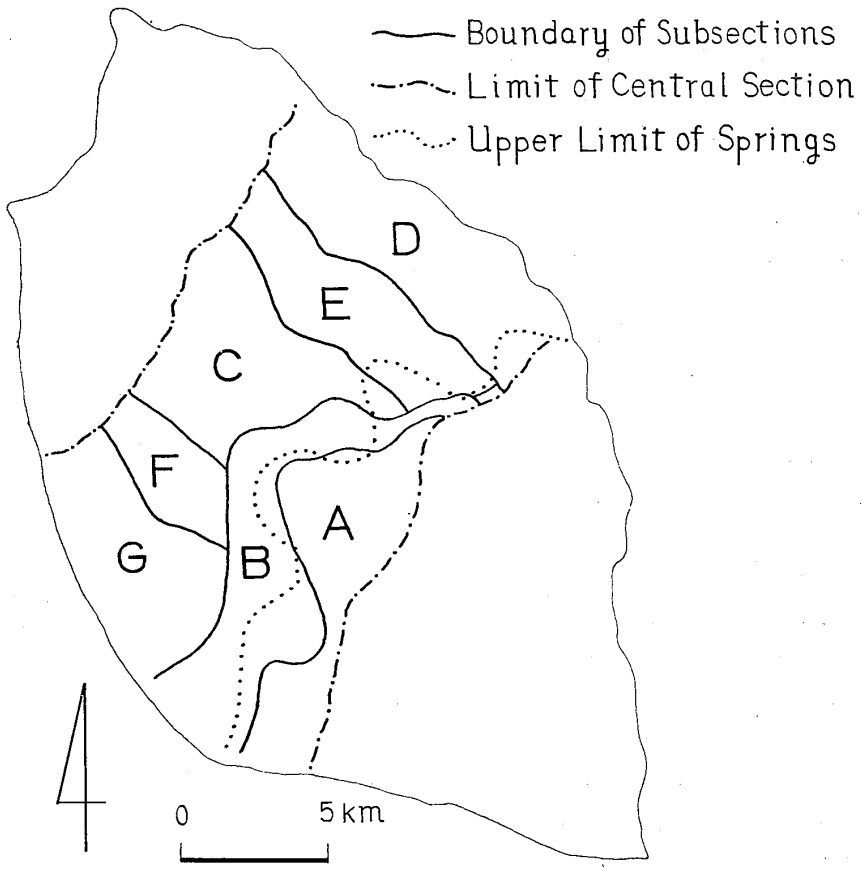


Fig. 1. A map to illustrate a series of seven subsections A, B, C, D, E, F and G, which are delimited on the basis of the surveys concerning the depth of the wells, the depth of the water table and the thickness of the water, which were practised in 1963. Although these surveys were carried out three times in 1963, the subsections are established in exactly the same way with regard to the respective observations.

subsections, in order to discriminate them from the new subsections.

In the present paper seven groups A, B, C, D, E, F and G, instead of six, are newly separated on the coordinate, concerning the respective surveys made in 1963. As a consequence, the central section is divided into the same number of corresponding subsections forming a series of contiguous regions which are illustrated in Fig. 1. These subsections are compared and contrasted in connection with the respective surveys as shown in Tables 1, 2 and 3, regarding the upper and the lower limits of the depth of the wells, the depth of the water table and the thickness of the water which are proper to each individual subsection. As for the observation made on Sept. 2 where the differentiation of the seven subsections is most clearly discriminated of the three surveys, graphic representation with seven polygons is illustrated in Fig. 2.

**The Seven Subsections.**

Through May 6–8, when the water table lowered in every subsection to its lowest level of the three observations, the thickness of the water was restricted to only 2 or 3 meters, similarly in all subsections with the exception of G (Tab. 1). There, accordingly, was

Table 1. Upper and Lower Limits of Depth of Wells, Depth of Water Table and Thickness of Water observed through May 6-8, 1963

| Symbols of Subsections | Upper and Lower Limits | | |
|---|---|---|---|
| | Depth of Wells | Depth of Water Table | Thickness of Water |
| A | 2.5— 5.5 | 2 — 5 | 0 —2.5 |
| B | 6 — 9.5 | 4 — 9 | 0.5—2.5 |
| C | 10.5—24 | 9 —21 | 0.5—3.5 |
| D | 9.5—27.5 | 6.5—24 | 1 —3.5 |
| E | 13.5—25 | 12.5—23 | 0 —3 |
| F | 8.5—12.5 | 6 —11.5 | 0.5—3 |
| G | 10 —23 | 7.5—17 | 1.5—5.5 |

found a contrast among these subsections only in connection with the depth of the wells and the depth of the water table as well. Therefore in the following discussions the characteristics of the subsections are compared exclusively with regard to the surveys of Jul. 23 and also of Sept. 2, when the water level rose in every subsection, though varying in amount, as compared with the level in May, so that the intersectional contrasts concerning the thickness of the water is more or less distinctly pointed out. Figs. 1, 2, 3, 4 and 5 and also Tables 2 and 3 may all serve for the present comparative study concerning the seven subsections.

(A) This subsection which occupies the southernmost part of the central section, is one of the smallest among the seven subsections, so far as the depth of the wells, the depth of the water table and the thickness of the water are concerned. Although the same characteristics were pointed out for former A, the upper limit of the depth of the wells in A remains smaller than that limit in former A because the southwestern corner of former A is newly ceded to B in the present paper. This corner, which is characterized by the wells attaining somewhat greater depths compared with the wells in the other parts of former A, was included in the same subsection in paper (1) only because of the small thickness of the water which was surveyed on Oct. 1, 1950.

Table 2 Upper and Lower Limits of Depth of Wells, Depth of Water Table and Thickness of Water observed on Jul. 23, 1963

| Symbols of Subsections | Upper and Lower Limits | | |
|---|---|---|---|
| | Depth of Wells | Depth of Water Table | Thickness of Water |
| A | 2.5— 5.5 | 1 — 3.5 | 0.5—3.5 |
| B | 6 — 9.5 | 1.5— 5 | 3.5—6 |
| C | 10 —24.5 | 3 —17 | 4.5—8.5 |
| D | 7.5—27.5 | 4.5—24 | 2 —4 |
| E | 13.5—25 | 7 —21 | 4 —9 |
| F | 8.5—12.5 | 4.5— 9.5 | 3 —4.5 |
| G | 10 —20 | 4.5—14 | 5.5—9 |

(B) This subsection which is situated contiguous to A, forms a narrow and curved zone, elongating along the northern and the northwestern boundary of A. The southernmost part of B, which covers the area of the above-mentioned southwestern corner of former

Table 3. Upper and Lower Limits of Depth of Wells, Depth of Water Table and Thickness of Water observed on Sept. 2, 1963

| Symbols of Subsections | Upper and Lower Limits | | |
|---|---|---|---|
| | Depth of Wells | Depth of Water Table | Thickness of Water |
| A | 2.5— 5.5 | 1.5— 3.5 | 0.5—3.5 |
| B | 6 — 9.5 | 2 — 5.5 | 3.5—6 |
| C | 10 —24.5 | 3 —17 | 5 —8.5 |
| D | 7.5—27.5 | 5.5—24.5 | 2 —4 |
| E | 13.5—25 | 8 —20.5 | 4 —9 |
| F | 8.5—12.5 | 5.5—10 | 1.5—3.5 |
| G | 10 —20 | 5 —15.5 | 4.5—7.5 |

A, extends farther to the south as compared with former B. The extent and the plane figure of B is determined first of all by the distribution of the depth of the wells and also to a certain extent by the distribution of the depth of the water table. Both isopleths representing the depth of the wells being 6 and 10 m respectively are decisive regarding the determination of the area of B. Accordingly, a sharp change in the depth of the wells from 6 to 10 m within a narrow belt is characteristic of B, which forms a striking contrast with A which is characterized by a large number of shallow wells between 4 and 6 m deep, making a homogeneous distribution area of a comparatively large extent regarding the depth of the wells. A marked contrast between A and B is afforded also by the thickness of the water, which is definitely larger in B than in A and which changes sharply along the boundary between A and B.

A series of contiguous subsections C, D, E, F and G, which lie north and northwest of B and which extend towards the apex area of the fan, is contrasted strikingly with A and B, concerning both the depth of the wells and the depth of the water table which are both markedly larger in C, D, E, F and G as compared with those depths in A and B. Since the depths of the wells increase rapidly

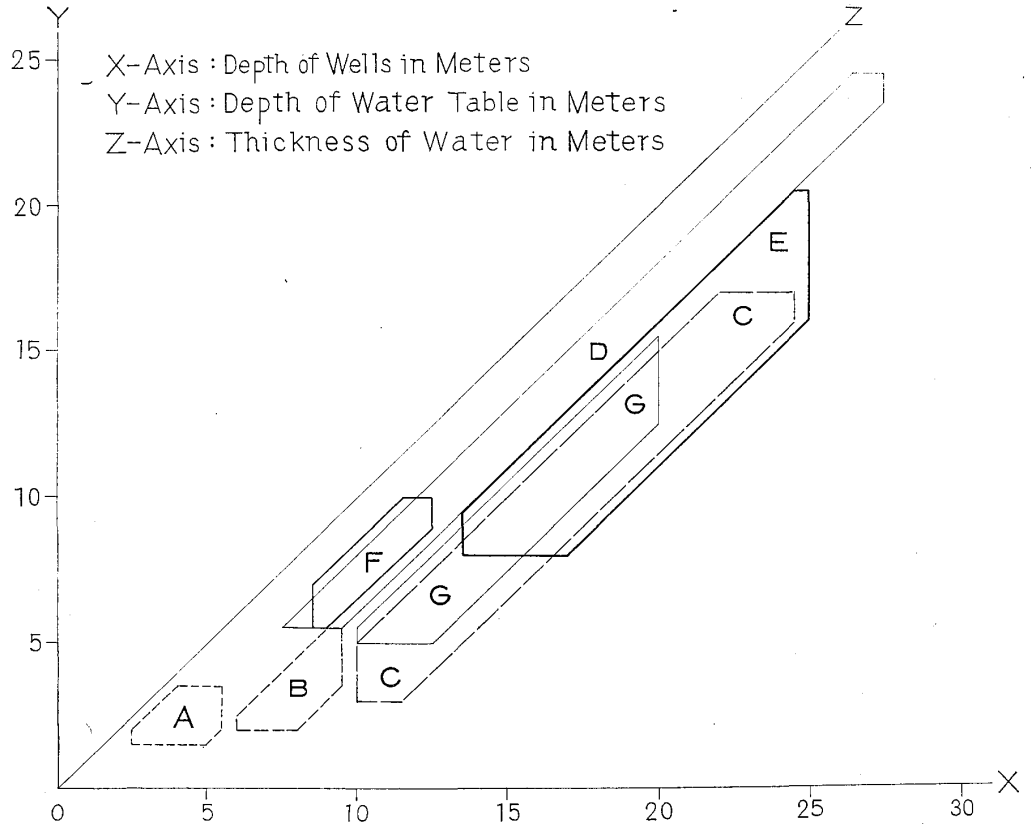


Fig. 2. A coordinate to illustrate the limits of the seven regional groups of the wells, which are represented, after the survey on Sept. 2, 1963, by seven polygons A, B, C, D, E, F and G. Compare with Fig. 1 and also with Tab. 3.

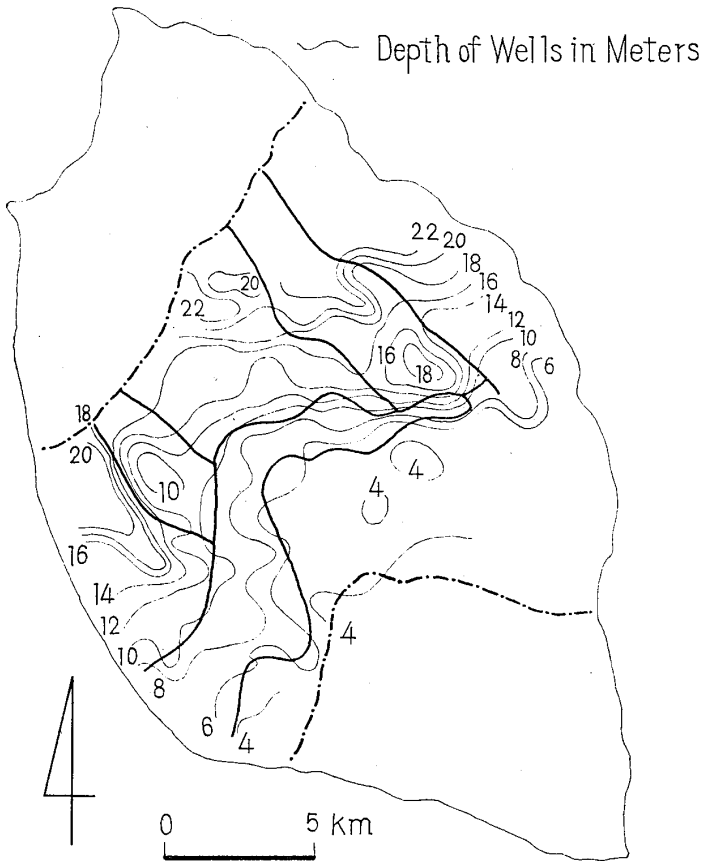


Fig. 3. A map to illustrate the distribution of the depth of the wells, which is represented by means of the isopleth. The boundaries of the seven subsections are entered in the map. The distribution area is somewhat extended as compared with the area in Figs. 4 and 5, because those surveys of Oct. 1, 1950 and of Oct. 17, 1961 are used jointly with the surveys of 1963. Although the form of the isopleths as a whole is quite similar to the form illustrated in paper (1), some differences are pointed out between the two as a result of these new surveys of 1963 which are taken into account for drawing the present map.

northwards and northwestwards or towards the apex area of the fan, the upper limits exceed 20 m in the northern part of each subsection C, D, E and G, and the difference between the upper and the lower limits ranges between 10 and 20 m according to the subsection. The depth of the water level which increases, as a general rule, keeping pace with the depth of the wells, reaches between 15 and 25 m also in the northern part of C, D, E and G. The newly separated subsection F which is composed of the eastern part of former F together with the southwestern corner of former C, is rather exceptional concerning the above-mentioned points, because the upper limits of both the depth of the wells as well as the depth of the water level in this subsection are rather smaller as compared with those limits in C, D, E and G. As for the thickness of the water, although it remains

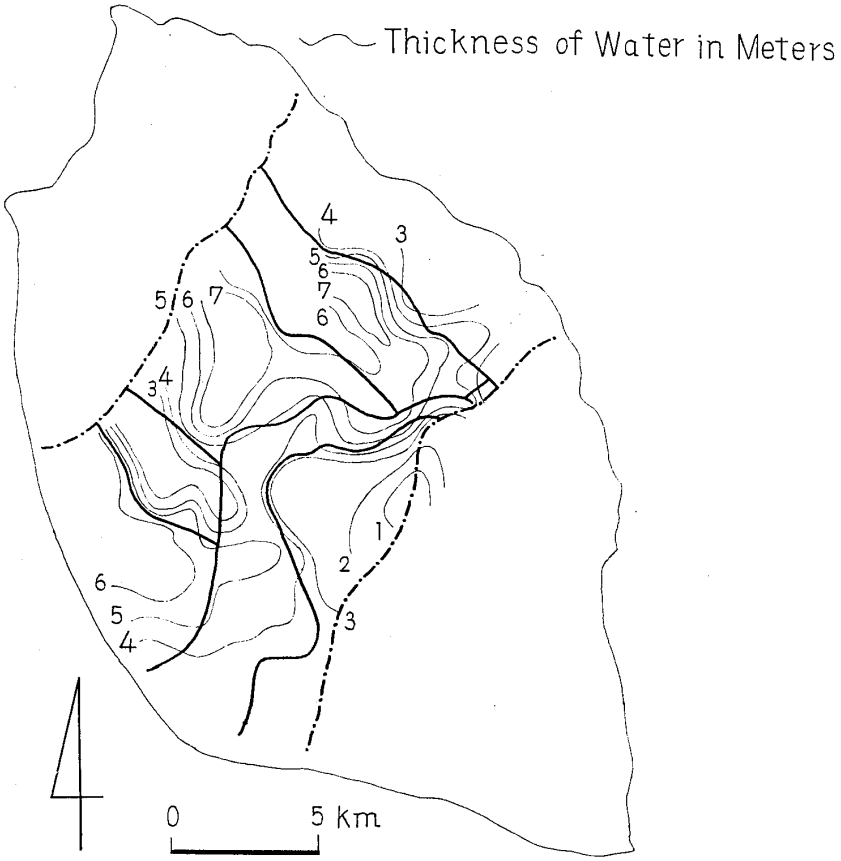


Fig. 4. A map to illustrate the distribution of the thickness of the water on Sept. 2, 1963, by means of the isopleth.

rather similar among C, E and G on the one hand and between D and F on the other, it exhibits a marked contrast between D and E, C and F and also F and G, each forming a couple of contiguous subsections. These intraregional contrasts constitute a main basis upon which the series of contiguous subsections C, D, E, F and G is established in the present paper. The delimitation between C and E, however, which form no such contrast with each other regarding the thickness of the water, will be mentioned in the next paragraph.

(C) This subsection which covers approximately the same area as that of former C, except for its southwestern corner, occupies the recent flood plains of the rivers Sabi and Kuma. Both C and E have almost the same limiting values concerning the thickness of the water and also exhibit no recognizable difference regarding the other characteristics of the wells, except that in C the lower limits of the depth of the wells as well as the depth of the water table are considerably smaller as compared with those limits in E, so far as the surveys of Jul. 23 and Sept. 2, 1963 are concerned. Therefore the delimitation of C from the contiguous subsection E is carried out in the present paper, following the boundary established in paper (1), on the basis

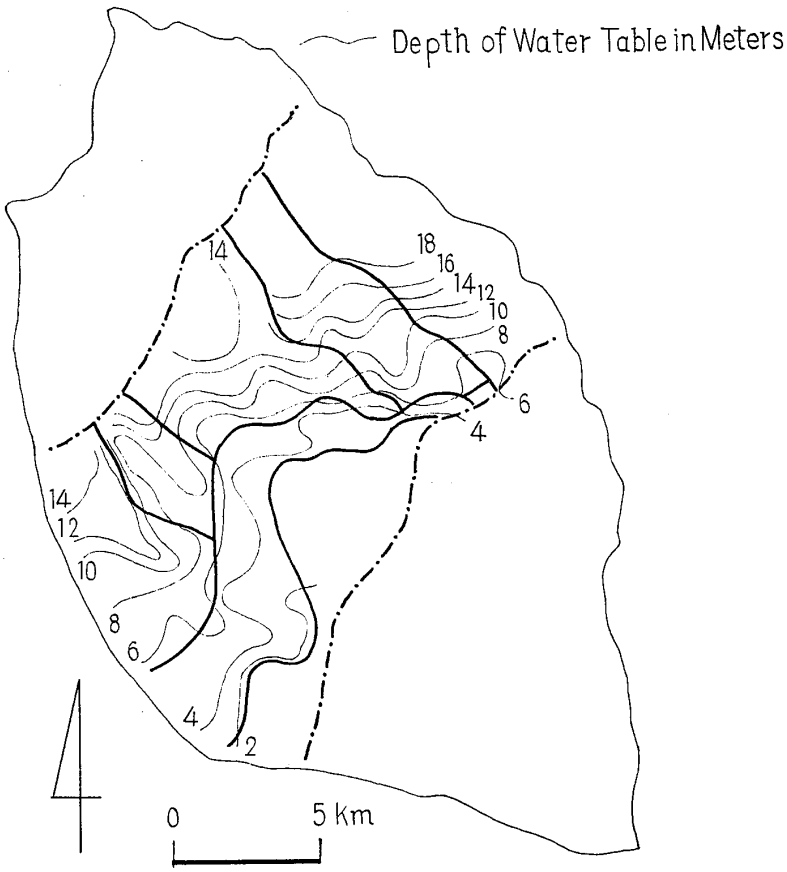


Fig. 5. A map to illustrate the distribution of the depth of the water table on Sept. 2, 1963, by means of the isopleth.

of the observation made on Oct. 1, 1950, when a rise in the level of the water occurred, in all probability, differently between C and E in such a manner as to be capable of distinguishing them regarding the thickness of the water. As for the thickness of the water, a considerable area with values attaining more than 7 m is pointed out in the northernmost part of C both on Jul. 23 and on Sept. 2, 1963, where a thickness even more than 12 m was recorded on Oct. 1, 1950, as mentioned in paper (1). Except for the western margin of G, C constitutes the main part of the old reclaimed area within the series C, D, E, F and G, where the settlements were formed before the Meiji era.

(D) This subsection occupies the eastern margin of the central section. Although the greater part of the central section is covered by the Nasuno-surface, some terraces along the river Naka and a part of the Chikasono-surface, both of which are lower than the Nasuno-surface, are included in D. The depth of the wells as well as the depth of the water table of the wells on these lower surfaces are, as a rule, smaller as compared with those depths of the wells on the Nasuno-surface. Except for those wells on the lower surfaces, D represents no conspicuous difference from E, regarding the upper and

the lower limits of the depth of the wells as well as the depth of the water table. On the other hand these two subsections are markedly contrasted with each other, in connection with the thickness of the water which is definitely smaller in D. Concerning the thickness of the water, such smallness of D was also recognized from the observation made on Oct. 1, 1950, on the basis of which former D was delimited from former E in paper (1). The boundary line between the present D and E which are discriminated in the same way, mainly with regard to the thickness of the water, is established somewhat differently, however, as compared with that line in paper (1).

(E) This subsection which is situated contiguously between C and D is markedly similar to C except that some wells in the southernmost part of C are smaller as compared with the wells in E, so far as their depth and the depth of the water table are concerned. The so-called Higashi-hara (Eastern-wilderness), of which the main part was settled after the Meiji era, covers approximately the combined area of D and E. Accordingly, within the Higashi-hara the small thickness of the water in D and the large depths of the wells together with the large depths of the water table in D and E may be the chief factors which hindered the cultivation of this wasteland before the Meiji era. Especially in the southernmost part of E, those large depths concerning the wells and the water table, which are sharply contrasted with those small depths in the contiguous old cultivated subsections A and B, are reasonably supposed to be the main factors in checking the expansion of the settlement from the old settled A and B. On the other hand, the southernmost part of C which is favored with the ground water conditions as mentioned above, was occupied by several old settlements already before the Meiji era.

(F) This subsection which is newly established in the present paper and which is situated between C and G is separated from C by the Fujinidayama-hill. The depth of the wells, the depth of the water table and especially the thickness of the water, everyone of which remains smaller as compared with those depths and the thickness in C and G respectively, differentiate F as a separate subsection. As for the thickness of the water, F is almost the same with D, and both were second in smallness only to A in the central section on Jul. 23 and also on Sept. 2, 1963. Such small thickness of the water in F changes sharply and becomes thick immediately beyond the boundaries between F and C on the one hand and between F and G on the other. The strikingly small depth of the wells as well as the small depth of the water table in the central part of F may be due to the shallow lying impervious bed near Akadayama- and other hills, which forms the bed rock of those small isolated hills.

(G) This subsection which is situated contiguously to the west of F, extends along the western border of the central section. The thickness of the water in G, which is definitely deeper than the thickness in F, differentiates G as a whole from the neighboring F. In addition all those important characteristics of the wells, i. e. the depth of the wells, the depth of the water table and the thickness of the water, change sharply along the boundary between F and G. Accordingly, F and G together form a couple of contiguous subsections, well-recognized and also well-defined. In other words the so-called Nishi-hara (Western-wilderness), which is composed approximately of F and G and which was mainly settled after the Meiji era excepting the western extreme border along the river Hôki, is in a similar way as the afore-mentioned Higashi-hara equipped with different ground water conditions as to the eastern and the western half of the region. So far as G is concerned, the thickness of the water observed on Oct. 1, 1950, which was somewhat smaller compared with those thicknesses surveyed on Sept. 2 and especially on Jul. 23, 1963, was similar to the thickness in the present F surveyed on the same date, i. e. on Oct. 1, 1950. This was the main reason why former F which covered the areas of G and F, was not divided into these subsections in paper (1). And at the same time this was perhaps also the main reason why the thickness of the water surveyed on Oct. 1, 1950 within the newly extended southernmost part of B was restricted to a smaller thickness as compared with those thicknesses observed on Jul. 23 and on Sept. 2, 1963, and, in consequence, why this part was treated as a part of former A instead of former B in paper (1) as mentioned above.

## Summary and Conclusion.

Within the central section of the Nasuno-basin which is discussed in the present paper, seven subsections A, B, C, D, E, F and G are established on the basis of the most important characteristics of the wells, i. e. the depth of the wells, the depth of the water table and the thickness of the water in the wells. The regional divisions are carried out in exactly the same way as in paper (1), taking the general relationship $y=x-c$ into consideration. Although two observations, i. e. those surveyed on Jul. 23 and on Sept. 2, 1963, are analysed equally in the present paper, the same series of subsections is recognized in connection with those different surveys. Besides, considerable similarities are found between the present series of subsections and the series established in paper (1) on the basis of the observation made on Oct. 1, 1950. The most noticeable difference, however, is that in the present paper F is newly delimited as a subsection which is situated between C and G and which exhibits a striking contrast with these

subsections, regarding those afore-mentioned basic characteristics of the wells. In spite of this and other minor differences, the similarity as a whole between the regional division in the present paper and the division in paper (1), which divisions are practised on the basis of the different surveys carried out on the different dates, may reasonably suggest the existence of some intimate relationships between these regional divisions and the systems of the ground water. Investigations into this point will be pursued in the near future in connection with the fluctuation of the water table. As far as the present paper is concerned, however, the most important facts regarding the regional differentiations of the seven subsections which are classified here into three categories viewed from the type of regions, are summarized as follows.

(1) A is the smallest among the subsections concerning those basic characteristics of the wells and is recognized as typical of the homogeneous region, i. e. the region in which those characteristics are confined within certain ranges of small extent. This subsection which is situated below the upper limit of the springs, covers the southernmost part of the central section and forms perhaps the main oldest reclaimed area within the section concerned.

(2) The series of contiguous subsections C, D, E, F and G, all of which extend from the southeastern to the northwestern part of the central section toward the apex area of the fan, is strikingly contrasted with A considered from the regional viewpoint. First of all, the depth of the wells as well as the depth of the water table in these subsections are, as a rule, far greater as compared with those depths in A. The most conspicuous characteristics common to these subsections, however, are the general growing tendency of those depths toward the apex area of the fan and, as a consequence, the wide ranges between the upper and the lower limits of those depths except in newly established F. Therefore, C, D, E and G which form characteristic heterogeneous regions in opposition to the homogeneous region A, are typical of the transition region viewed from another angle, as far as the depth of the wells and the depth of the water table are concerned. The thickness of the water which remains similar among C, E and G on the one hand and between D and F on the other is considerably larger in the former group as compared with the latter. Within the series C, D, E, F and G the delimitation of the subsections is carried out in connection with the thickness of the water. The boundary line between each contiguous subsection is therefore drawn where a sharp change in the thickness of the water occurs. Only between C and E the boundary line is established as in paper (1).

(3) Between A on the one side and the series of subsections C,

D, E, F and G on the other, a region of a different type is recognized, i. e. a long and curved belt of B. This subsection is almost exactly determined as forming a distribution area of those depths of the wells, which change sharply within a short distance from the upper limit of the depth in A to the lower limit of the depth in the series C, D, E, F and G. Therefore, B, which is situated between A and the series, is not only typical of the transition region, but also typical of the sudden transition belt. The thickness of the water in B, which is limited within a certain range of small extent and which remains between those thicknesses in C, E and G on the one hand and those in D and F on the other, forms one of the bases upon which B is delimited from the series in question. Between this thickness in B and the thickness in A which is decisively smaller than the former, a sharp contrast is recognized especially along the northeastern boundary between these two subsections A and B. The northern limit of the springs occurs, as a general rule, through the area of B where not a few old settlements before the Meiji era were established especially beyond the northern boundary of A.

The present author has to acknowledge his indebtedness to the Scientific Research Grant of the Ministry of Education for the year 1964. He is also deeply indebted to the Kantô Regional Office (Kantô Nôsei-Kyoku) of the Ministry of Agriculture and Forestry for the ample facilities afforded to him to make use of the data analysed in the course of this study. His cordial thanks are also due to Miss Setsuko Okazaki for her kind assistance extended to him in analysing the data.