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Small gasoline engine raising Santa Cruz underflow for irrigation.

The Underground Waters of Arizona—Their Character and Uses.

BY W. W. SKINNER.

Tucson, Arizona, October 12, 1903.

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION

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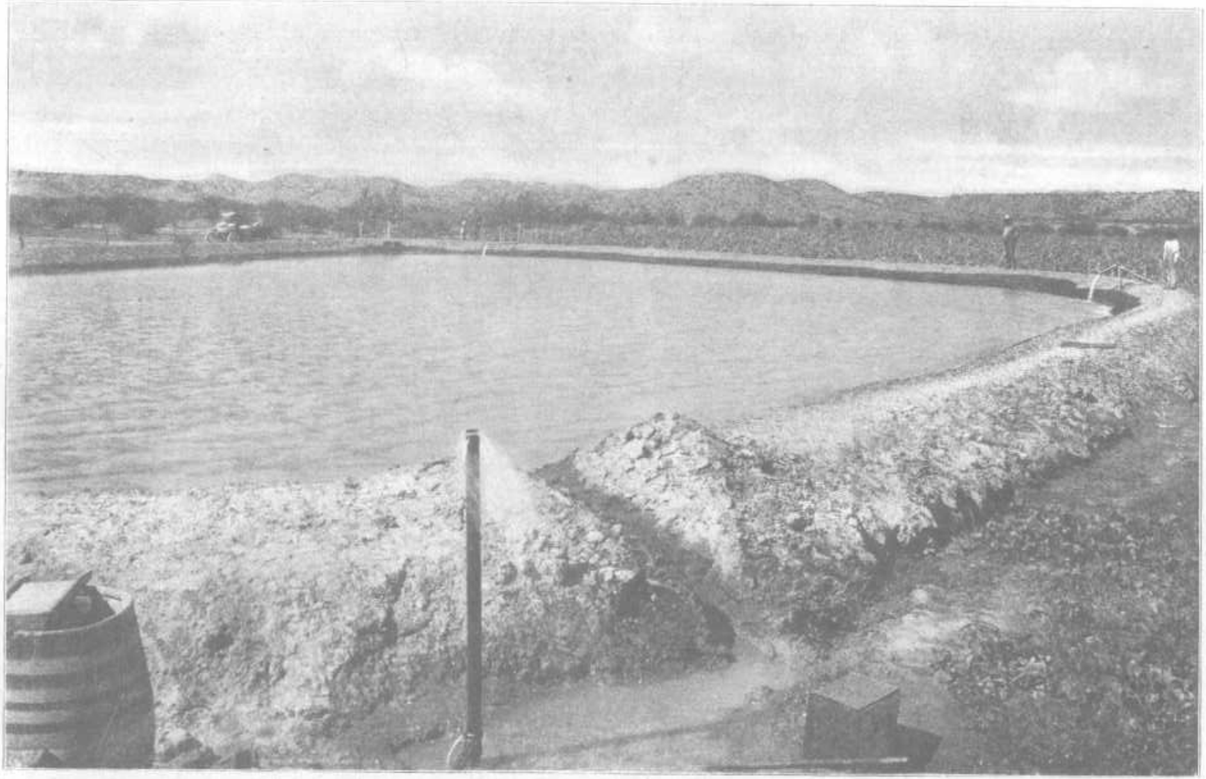

Typical Artesian Well and Reservoir near St, Davids, Arizona.

THE UNDERGROUND WATERS OF ARIZONA —THEIR CHARACTER AND USES.

By W. W. Skinner.

This bulletin is a compilation and discussion of the results of an examination of the ground waters of the Territory as to their suitability for sanitary, irrigation, and technical uses.

The results are sufficiently exhaustive to afford certain definite conclusions, which are believed to be a matter of general public interest at a time when more and more attention is being devoted to the development of ground waters for irrigation, municipal and other uses.

CLASSIFICATION.

Waters may be classified, according to the purpose for which the supply is used, into three divisions; namely, sanitary, irrigation and technical. The chemical examination to which a sample is subjected, the interpretation of results, and the standards of purity adopted vary according to the class to which a sample belongs.

SANITARY STANDARDS OF PURITY.

Some authorities upon the examination of waters, and the correct interpretation to put upon the same, lay great stress upon certain hard and fast rules for judging as to the potability of a water, adopting fixed standards according to which a sample is pronounced good, bad or doubtful. These standards are, however, distinctly local in their application. Judged by standards adopted by Eastern authorities, nine-tenths of the drinking waters of Arizona would be condemned upon their content of soluble salts alone; yet, to persons accustomed to the strongly sulphated and carbonated waters that occur in certain sections of the Southwest, the supply is entirely agreeable, and apparently uninjurious.

One of the first things to know in judging of the character of a water, is the condition of the surroundings of the source of supply. The statement of results may mean very little indeed, even to an experienced chemist, unless considered in connection with such conditions. One instance will sufficiently illustrate the point. A sample of water is found upon examination to contain large quantities of free ammonia. If such a water is from a shallow well or spring, the conclusion is that the source of contamination is near at hand and in an active state of decomposition—probably some form of sewage, or the drainage from a cesspool. Such a water should undoubtedly be condemned. On the other hand, if the sample comes from a deep well, the interpretation would be entirely different. In this case, in the absence of surface contamination, the conclusion would be that in some period of its history the water, containing nitrogen in the form of nitrates or nitrites, probably came into contact with reducing substances, such as some of the iron salts, ammonia thereby being formed. Such a water should not be condemned.

A point of considerable interest in regard to the well waters of Arizona is their uniformly high content of nitrates Here again we cannot be governed by Eastern standards, but are compelled to adopt a standard applicable to local conditions. A very high percentage of nitrates, which would condemn an Eastern water, may be looked upon here as a very natural effect of our semiarid conditions. Nitrification takes place with extreme rapidity in this climate, and as the nitrates are soluble, we would naturally expect to find them in large quantities in our well waters, and in the seepage waters from the irrigated districts; and this is what we do find to be true. Being an inert and harmless form of nitrogen, however, and the effect of natural causes as stated above, too great significance should not be attributed to the presence of nitrates, even in relatively large amounts.

As to the harmful effects of the large amounts of so-called alkali salts found in solution in the well waters of Arizona which are used for drinking purposes, expert opinion differs. Some physicians state that waters highly charged with sulphates of lime and magnesia are prone to produce disorders of the stomach, calcareous concretions in the system, and phosphatic calculi* On the other hand, many of our spring and well waters very nearly approach noted mineral waters, as the Kissingen Springs of Bavaria, renowned throughout the civilized world for their curative effects in certain disorders. Indeed, the curative properties of some of our Arizona springs are becoming well known, notably Iron Springs near Prescott, and Agua Caliente southwest of Phoenix.

Water for drinking purposes is continually in danger of inoculation by dangerous bacteria, especially the water of surface wells; but if the supply contains little or no organic matter, which is the food upon which bacteria live, it naturally follows that the chances of its becoming permanently dangerous are remote. On the other hand, when such organic matter is present in great abundance, the conditions are favorable to the rapid growth and multiplication of the bacteria. When it is considered that one single bacterium, reproducing by division, may, theoretically, increase to over sixteen and a half millions m twenty-four hours, the importance of knowing the presence of sufficient organic matter to bring about such a condition is seen to be indeed vital. A bacteriological examination is necessary, of course, to determine the presence or absence of a specific bacterium, and is absolutely necessary when a water is already suspected of causing a specific disease; but a chemical analysis is usually of greater general importance, as it indicates not only its past and present character, but what reasonably may be expected of the supply in the future.

WATERS FOR IRRIGATION.

The use of well waters for irrigation, with the exception of those from artesian wells, is as yet in its infancy in Arizona; although considerable developing is being done along this line in different localities, notably near Mesa, by Dr. A. J. Chandler.

The serious difficulty where water has to be pumped for irrigation is the cost of fuel. With the advent of cheaper power, the question may be solved in certain localities, as is notably the case in Southern California.

In the district above Safford and Thatcher, on the upper Gila, and at Saint David on the San Pedro, artesian water has been obtained, There is already quite an area of land irrigated from this source, and it is probable that the amount so irrigated will be largely increased in the near future. The first well in the Saint David district was bored in 1899. The well was on the east bank of the San Pedro, and was about 450 feet deep. Since then much property has been located in this vicinity, and artesian water has been developed on both sides of the river, there being now about 210 artesian wells in this locality.

While the upper Gila and San Pedro valleys are the first to be successfully exploited for artesian water, it is very probable that it can be developed in other valleys of Arizona, the solution of the problem—where water can be obtained—depending entirely upon the first cost and permanence of the well, and the value of the land which could be utilized.

The cost of artesian wells, of course, varies with the depth of the water-bearing stratum below the surface. Other factors which affect the cost are the size of the well and the character of the various strata through which the well passes. The average cost is probably between fifty cents and two dollars per foot.

The prospect is an inviting one, and seems to give evidence of being profitable. However, the water from all of the artesian wells so far developed in Arizona is more or less black-alkaline,—that is. contains sodium carbonate and bicarbonate,—which is a serious factor that must be reckoned with. This will be brought out in greater detail in the discussion of artesian wells, page 282,

The quantity of soluble salts allowable in water for irrigation purposes, varies with the composition of the salts, the methods of irrigation and culture, the drainage, the character of the soil and the kind of crop grown. Professor Forbes, who has given the subject much attention, states in Bulletin 44 that, with the prevailing agricultural practice in Salt River Valley, irrigating waters containing 100 parts of salts of average composition in 100,000 parts of water are liable in a few years to cause harmful accumulations of alkali, and that the use of such waters, must be attended with precautionary care.

WATERS FOR TECHNICAL USES.

For steam.—The most general and important use of water in a technical way is for the production of steam. It is therefore of the highest importance to know the quantity and composition of salts held In solution by the water to be supplied to steam boilers. To develop one horse power per hour requires about 3½ gallons of water; therefore, a 100 horse power engine running 10 hours requires about 3,500 gallons of water. An average of the soluble salts in the underground waters of Arizona is approximately 135 parts in 100,000 of water. From such a water there would remain in the boiler at the end of a ten-hour run between 39 and 40 pounds of salts.

For boiler use, judged by undesirable qualities, waters may be divided into three classes; namely, scale-forming, corrosive, and foaming or priming. By far the most common in this Territory is the scale-forming class.

Boiler deposits, including scale-forming salts, are largely composed of the sulphates and carbonates of lime and magnesia. Calcium sulphate is decidedly the most objectionable of the scale-forming salts. Alone, or when mixed with a relatively small amount of calcium carbonate, it forms a hard metal-like scale which is a very poor conductor of heat and extremely difficult to remove from the tubes and boiler plates. This scale is a non-conductor of heat, and therefore prevents the maximum efficiency being obtained from the fuel used, thereby increasing the cost of producing steam. The loss of heat varies with the composition of the scale, the harder kinds being as a rule the more perfect non-conductors. One authority* places the loss of fuel at an average of 8 per cent for every 1-16 of an inch of scale, making a loss of 64 per cent for a half inch of scale.

In addition to the loss of fuel, boiler scale may cause disaster if the deposit is allowed to become sufficiently thick, as the plates and tubes may then be heated until red hot, when, if the scale should crack or flake off, the water suddenly coming in contact with the overheated metal would be liable to cause an explosion. The overheating of the plates and tubes also causes them to warp, thus seriously weakening the boiler.

Water containing carbonate of lime alone, or in a large proportion to the sulphate, forms a soft mud-like deposit that does not readily adhere to the plates and may be blown off. Sulphate and carbonate of magnesia are similar in character to the lime salts, but are usually present in very small amounts.

*Wahl & Henius.

Water containing magnesium chlorid produces a rapid and disastrous corrosion of boiler plates. This is due to the fact that magnesium chlorid is not a very stable compound and readily undergoes decomposition at the high temperature and increased pressure obtained in steam boilers. The product of this decomposition causing the trouble is hydrochloric acid, popularly called muriatic acid. Being a volatile compound, it escapes with the steam, and not only seriously corrodes the boiler plates, but also the steam pipes, valves, etc.

Priming or foaming is caused by muddy water, by the formation of soft scale, or by alkaline water, that is, water which contains carbonate of soda, which is frequently found in the well waters of Arizona. It is also frequently caused by an excessive use of scale preventives, which as a rule contain some form of alkali.

The theory of scale preventives is based upon the fact that certain of the alkalies will precipitate in a soft condition the troublesome lime and magnesia salts which may then be blown off; but, as an excess of the alkalies in a water causes almost as much trouble as the scale, it follows that just enough of the alkali should be used to combine with the lime and magnesia. Hence, in order to get the best results from a scale preventive, it is necessary to have it compounded expressly for the water to be treated by it.

For brewing.—For brewing it is essential that the water used shall be of the highest organic purity, and the soluble salts also exert a very marked influence upon the product To produce the best pale beer or ale, a hard water, poor in carbonates, is desirable, that is, one containing calcium sulphate. 30 to 40 parts in 100,000 is considered the correct amount by authorities upon this subject. On the other hand, very soft water is desirable for the production of dark beers and porter, as soft water leaches out more of the extractive and coloring matter from the malt.

For laundry purposes.—The character of soluble salts is of great importance when water is to be used for laundry and domestic purposes. The amount of soap wasted is proportional to the content of lime and magnesia salts, the presence of these salts causing the water to be called hard water. Soap is a combination of fatty acids with some base, nearly all of our commercial brands being either soda or potash soaps. Now, when soap is added to a water containing lime and magnesia salts, a reaction takes place, the soda soap is decomposed and the corresponding lime or magnesia compound formed, which is insoluble. It therefore follows that none of the soda soap is available for cleansing purposes until all the lime and magnesia salts present have been combined in this way. The lime and magnesia salts are also objectionable because the new compounds formed have an undesirable effect upon fabrics, especially woolen goods, causing an unpleasant odor and shrinkage.

The extra cost, in soap, of using a hard water is likely to be thought an item of little importance; but this is by no means the truth. Dr. Mason, an authority upon waters, states that each grain of carbonate of lime, or its equivalent, per gallon of water, causes an increased expenditure of about 2 ounces of soap for every 100 gallons of water. It is not unusual for well waters of Arizona to contain 30 parts of lime per 100,000, stated as carbonate, which is equivalent to about 18 grains per gallon. The use of such water in a family of five persons would probably cause an actual waste of several dollars worth of soap a year,

Very hard waters may be satisfactorily and profitably treated before being used for laundry purposes by adding an amount of sodium carbonate (washing soda) proportional to the amounts of lime and magnesia present. The water should then be boiled for a few minutes (all the lime salts being thereby precipitated), allowed to settle, and then drawn off from the sediment.

For sugar making.—Another technical process in which water plays a very important part is the manufacture of sugar from sugar beets,—a fact which is of special interest in connection with the building of a beet-sugar factory in Salt River Valley at the present time.

For sugar-making purposes, sodium chlorid, or common salt, which is far the most abundant in our Arizona waters, is the least troublesome; while nitrates and alkali carbonates are the most undesirable. The action of these latter salts is to prevent the crystallization of the sugar in the concentrated juice. It is stated that a nitrate will prevent six times its weight of sugar from crystallizing. As shown in Bulletin 30 of this Station, an ordinary beet factory, using 200,000 gallons of water daily, would lose approximately $10 a day for each ten parts of soluble solids in the water used. A factory operating with a water containing 50 parts of salts to the 100,000, for 60 days, would lose therefore from this cause approximately three thousand dollars for each season's run.

THE SANTA CRUZ UNDERFLOW.

The underflow of the Santa Cruz valley may be divided, according to the chemical nature of the dissolved salts, into two distinct classes of water; namely, hard and soft.

The analyses of the waters of those wells which tap the underflow of the Santa Cruz river above its confluence with the Rillito are shown in Table I, from which it will be seen that a large percentage of the salts in solution are compounds of lime and magnesia, existing both as carbonates and sulphates. These waters are, therefore, both temporarily and permanently hard. The lime and magnesia salts are more abundant in the waters of the upper than in those of the lower Santa Cruz, as is shown by a comparison of the analyses of the waters around Nogales with those near Tucson.

By reference to Table I, it will be seen that the water near Nogales and Calabasas contain on an average about 45.6 parts total soluble solids, and 14.9 parts permanent hardness expressed as calcium sulphate in column No. 7; while, coming down the valley, the waters gradually change for the better, the total soluble solids gradually decreasing, and the permanent hardness in some instances entirely disappearing. This is easily accounted for, however. It is known that along the upper slopes of the valley there are large beds of gypsum and limestone, and, since the mineral character of a water is influenced by the nature and character of the mineral deposits with which it comes in contact, we should naturally expect the waters of the upper Santa Cruz to be charged with lime salts. Coming down the river towards Tucson there is a considerable influx of water from the Santa Rita Mountains, the character of which is shown in Table I. No. 2932 is from a spring in Madera Canyon, and No. 2935 from a well at Hart's Ranch on the east side of the Santa Cruz, and both are seen to be black-alkaline waters. With this information we are able to account for the decrease in total soluble solids and the partial disappearance of the hard character of the water in the lower valley. The water from the Santa Ritas being alkaline (containing sodium carbonate) and the Santa Cruz above the point of influx containing lime salts, there should be a chemical reaction when the two unite tending to precipitate the salts of lime and magnesia; but, as the volume of water coming from the Santa Ritas is probably very much less than that coming down the Santa Cruz, the effect, indicated by analyses, is to modify instead of entirely altering the character of the flow in the lower valley as compared with that of the upper.

In general, it may be said that the waters of the Santa Cruz underflow above Tucson are hard, bicarbonated, saline waters, containing a considerable quantity of sodium sulphate or Glauber's salts.

The other distinct supply in the Santa Cruz watershed is the Rillito underflow, which joins the Santa Cruz below Tucson. By reference to Table II, it will be seen that all the waters in this area are black-alkaline and it will be noticed that in this case, also, the waters of the upper valley are the more heavily charged with soluble salts. Thus the Agua Caliente contains 52 o parts of total soluble solids and 7.42 parts sodium carbonate, while the well at the University, in the same water zone, contains only 24.8 parts of total soluble solids and 3.5 parts sodium carbonate. This change is quite probably brought about by the influx of water from the Sabino Canyon district, which is by far the purest water in the vicinity of Tucson. The Rillito underflow also carries a small amount of lime salts in the form of bicarbonates, and therefore presents the somewhat anomalous condition of being a soft water, but temporarily hard.

The economic value to any locality of having two distinct sources of supply near at hand is worthy of consideration by those contemplating the erection of factories and other institutions requiring much water. For instance, for laundry and boiler purposes, water from the Rillito underflow is undoubtedly superior; while for irrigation, brewing, and some other technical purposes, where a calcareous water is desirable, the Santa Cruz underflow is very much better.

For drinking purposes, without considering possible local organic contamination, the Rillito underflow is superior to that of the Santa Cruz A comparison of the Tucson city supply and the University supply, which are representative of the two underflows, shows the latter to contain less total soluble solids and less lime and magnesia salts; although, on the whole, the supply from the city water works of Tucson is in purity much above the average to be found in most sections of the Southwest

ARTESIAN WELLS.

Flowing wells have been developed for irrigation purposes in but two localities in Arizona; namely, the upper Gila in and around Safford, where about thirty wells are flowing, and on the San Pedro near Saint David, where about 210 wells are in operation.

By reference to the appended table of analyses, No. III, it will be seen that all of the artesian waters so far developed in Arizona have one important common characteristic, which is that they contain sodium carbonate or black alkali. Mud Spring well on the east slope of Mt, Graham, which is the strongest one in this respect so far examined, contains 19.6 parts black alkali per 100,000 parts of water. This means that every acre-foot of this water used for irrigation would carry upon the soil 534 pounds of black alkali, and since approximately four acre-feet are necessary for all the year round irrigation, it follows that such a water would carry on to each acre of soil 2136 pounds of black alkali every year, the injurious effect of which would undoubtedly be manifest in a very few years unless some means were adopted to counteract it. The most effective method of accomplishing this is by a system of flooding and underdrainage, especially in a heavy soil where the natural underdrainage is poor. Under this treatment a portion of the salts is carried away in the seepage water, and that which is left is carried down and away from the surface and more evenly distributed through the lower soil where it will do the least possible injury.

Where in rare instances it is possible to do so, it would be wise to use artesian water to supplement the usual stream supply, as the sulphate of lime commonly contained in the latter,* under proper conditions of moisture, aeration and temperature will react with the black alkali of the artesian waters and produce carbonate of lime and sulphate of soda, which are not so injurious to plant life. Or, the artesian water may be used during the period of low surface flow and when the rains come and surface water is abundant, a thorough flooding of the land will materially decrease the injurious effect from artesian accumulations.

SALT RIVER VALLEY UNDERFLOW.

The ground waters of Salt River Valley, generally speaking, are relatively high in their content ot soluble salts, varying from 27.6 to 531 8 parts per 100,000 As shown in Table IV, the average is much above 100 parts in 100,000, which is the maximum amount believed to be allowable in irrigation practice in . Salt River Valley,

A comparison of the well waters of the Valley with those of the Salt River is interesting. In Bulletin 44, it is shown that the average content of soluble salts in Salt River for 1899-1900 varied from 52.5 to 157 parts per 100,000, and that the river water is normally a hard water—that is to say, lime and magnesium salts are present as carbonates and sulphates. It is also shown that at certain storm periods, when the influx of water is mostly from the mesas, the character of the river water sometimes changes from a hard to a black-alkaline condition, caused by the washing into the river of black-alkaline accumulations; but that the river resumes its normal character very shortly after each storm period has passed.

This accumulation of black alkali on the surface of the mesa is confirmed by the examination of the ground waters of the Valley. The shallow wells are frequently found to contain black alkali, while the deeper wells (those 100 ft. and more in depth) are characterized by the lime and magnesium salts which they contain. By referring to Table IV, it will be seen that, with very few

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*See Arizona Station Bull, 44, pp. 212, par. 13.

exceptions, the black-alkaline wells are shallow, these wells containing sufficient alkali to make it a serious consideration indeed, if such waters alone are to be relied upon for irrigation purposes. Fortunately, as before stated, the lower water-bearing strata yield an entirely different supply, and one which is very similar in character to the normal supply from Salt River, but usually containing a higher percentage of soluble salts.

Until within the past two years, few reliable data were available from which to form an idea of the variations in character of the different water-bearing strata of Salt River Valley; but some work is now being done along this line. The efforts of Dr. A, J. Chandler, near Mesa, have cast considerable light upon the subject. By referring to Table IV, the varying character of water coming from the different water-bearing strata underlying this section of the Valley is strikingly apparent.

Sample No. 2804 is from a shallow well about 54 feet deep, located in the N. E. ¼ of Sec. 27, T. 1 S., R. 5 E. This water is strongly black alkaline, containing 7.63 parts of sodium carbonate. Each acre-foot of this water would carry on to the soil about 208 pounds of black alkali, an amount which would undoubtedly cause ill effects in time, if the water were used continuously.

In Sec. 22, immediately north of Sec. 27, Dr. Chandler has bored a number of deep wells, the deepest being 705 feet; and while these deep wells usually contain a larger amount of soluble salts, they are shown by the analyses in Table IV, to be invariably hard waters. The hard water from the deeper water-bearing strata is an antidote for the harmful black alkali contained in the water from the shallow well, making it possible to combine these waters in proportions disposing of the most harmful black-alkaline constituent-

This change of character is again clearly shown by the deep well of Mr. Thomas Murphy, on Sec. 30, T. 2 N., R. 4 E., south of the Arizona canal.

In Table IV, Nos. 2837, 2838 and 2839 are samples taken from the same well but at different depths. No. 2839 was taken when the boring had reached a depth of 78 feet, and the analysis shows that at this level the water contained 388 parts per 100,000 of soluble salts, of which 45 2 parts are sodium carbonate or black alkali. In sample 2838, from the same well at 168 feet, the total solids had decreased to 303,2 parts, and the character of the water was entirely different from the previous sample, being decidedly a hard water, and containing the equivalent of 26.65 parts per 100,000 of sulphate of lime. At 187 feet the water was also hard, but contained less sulphate of lime than did the preceeding sample. No. 2842 was from the same well at a depth of 325 feet, and the analysis shows it to have been very similar to samples 2837 and 2838.

The deep well waters so far developed probably contain too high a percentage of soluble salts to be used continuously as a source of irrigation supply. An acre-foot of water containing 200 parts of soluble salts to the 100,000 would carry on to the land about 5,445 pounds of these salts. Estimating 3½ acre-feet as the minimum year's supply, such a water would carry on to each acre so irrigated the enormous quantity of about 19,000 pounds, or 9½ tons a year. However, the development of such a supply is often desirable in order that the irrigator in an emergency may supplement his usual supply from the river. This is especially applicable to orcharding in Salt River Valley. In fact, it would seem to be unwise, in view of the experience gained during the recent years of unusual drouth, to engage in orcharding upon a large scale without such an emergency supply. During periods of low water in the river, which frequently occur when water is most needed, the pumping of the underflow could be resorted to with great advantage to the orchard so irrigated, even though the water should contain an excess of alkali salts, as any undesirable accumulation of salts may be materially decreased by thoroughly flooding the land with the river flood waters as soon as they are available. The river at the time of flood usually contains a comparatively small quantity of saline materials, and by its use much of the alkali accumulated during the irrigation with well water may be leached out; and if this is supplemented by a good system of under drainage, only favorable results are to be anticipated.

It would also be highly desirable to have such an emergency supply in general farming. The cost of fuel and the necessary expense of operating pumping plants make it impracticable how ever for most small farmers. If the time ever comes however, when cheaper power is available in Southern Arizona we may expect a development along this line similar to that which has occured in several of the fruit-growing districts of California.

MISCELLANEOUS.

Table V, contains the analyses of miscellaneous samples collected throughout the Territory, not a sufficient number coming from any one point, however, to enable us to draw definite conclusions as to the character of any local supply. Some of these analyses are of particular interest from sanitary and technical points of view. No. 2294, the Prescott city supply, is shown by the analysis to be an unusually good water for sanitary purposes. The samples from the Buckeye country and the lower Colorado are invariably high in total soluble salts, which consist chiefly of sodium chlorid (common salt) and sulphates of lime and magnesia. Sample No. 2803, from Clifton, is remarkable for the large amount of salts which it contains, consisting chiefly of sodium chlorid. One hundred gallons of this water contains approximately 9.6 pounds of salts, or about one-third as much as sea water.

Sample No. 3162, is from a crater near Hunt, Apache Co., and is also worthy of notice. One hundred gallons of this water contains in solution the enormous quantity of 170 pounds of salts, of which 157 pounds is in the form of common salt.

DEFINITIONS AND APPROXIMATIONS.

In stating the results of analyses or observations upon the volume or rate of flow of water, certain terms are used such as *acre feet* and *parts per 100,000.* Frequently it is desirable to convert one statement into terms of another for more convenient use; for instance, to change *cubic feet per second* to *acre feet, parts per 100,000* to *grains per gallon*, etc.

A few definitions and approximations are appended below which, it is believed, will be found valuable:

An *acre foot* of water, is equivalent to an acre covered with water one foot deep, and is equal to 43,560 cubic feet, or, approximately, 326,700 gallons.

To change *second feet of flow* to *acre feet per day*, multiply by 1.984.

To change *parts per 100,000* to *pounds per acre foot*, multiply by 27.225.

To change *acre feet* to *gallons*, multiply by 43,560, and the product by 7½.

To change *parts per 100,000* to *grains per gallon*, multiply by .5833.

SANITARY STANDARDS OF PURITY,

For the judging of water for sanitary purposes in Arizona, the following standards of purity are proposed:

Total soluble solids,	From	0.	to	50.00	parts	per	100,000	Good
	From	50.	to	100.00	“	“	“	Fair
	From	100.	to	200.00	“	“	“	Acceptable
	Above			200.00	“	“	“	Bad
Nitrates,	From	0.00	to	0.20	“	“	“	Good
	From	0.20	to	1,00	“	“	“	Fair
	Above			1.00	“	“	“	Doubtful
Nitrites,	From	0.00	to	0.01	“	“	“	Good
	From	0.01	to	0.10	“	“	“	Fair
	Above			0.10	“	“	“	Bad
Free ammonia,	From	0.00	to	0.005	“	“	“	Good
	From	0.005	to	0.010	“	“	“	Fair
	Above			0.01	“	“	“	Doubtful
Albuminoid ammonia,	From	0.00	to	0.005	“	“	“	Very Good
	From	0.005	to	0.015	“	“	“	Safe
	Above			0.015	“	“	“	Doubtful

TABLE I—SANTA CRUZ VALLEY UNDERFLOW.

No	LOCATION Arranged in order going down Santa Cruz Valley	DATE	Depth	Parts in 100 000								QUALITATIVE		
				Total Soluble Solids @ 110° C	Chlorides Na Cl (Common Salt)	Hardness $Ca So_4$ Sulphate of Lime)	Alkalinity $Na_2 Co_3$ (Black Alkali)	*Nitrogen in the form of Nitrites	*Nitrogen in the form of Nitrates	Ammonia, Free	Ammonia Albuminoid	*Sulphates	*Magnesia	*Lime
1579	Nogales City Supply	6 25 97		15 9	1 5									
2742	R R Co 's Well, Nogales	10 14 01	65	27 6	4 0	7 6		f	1 05					
2743	Electric Light Co Nogales	10 14 01	35	37 4	6 0	8 4		0092	1 33					
2744	Joe Carbon Nogales	10 14 01	35	42 6	9 2	16 6		f	1 37					
2745	Water Works, Nogales	10 14 01	15	17 8	2 0	1 36		f	60					
2746	Thos Turner Nogales	10 14 01	15	15 6	2 0			n	f					
2747	T F Brown Nogales	10 14 01		26 8	4 8	5 44		0012	1 00					
2344	Cienega Spring Calabasas	3 1 00		65 4	3 8	26 3		n	098			v s	v s	v s
2345	M R Wise Calabasas	3 1 00		57 4	3 8	23 0		0222	094			v s	s	v s
2346	Agua Frijala Calabasas	3 1 00		90 0	4 8	34 1		0664	025			v s	v s	v s
2257	Mine water north slope Santa Ritas	1 11 00		18 2	2 5		4 7					s	s	s
2258	Saw Mill Canyon Santa Ritas	1 11 00		26 5	1 5		2 6					s	s	s
2787	Mine water north slope Santa Ritas	9 24 01		24 0	3 2	1 36								
2932	W Slope of Santa Ritas	10 15 02		33 0	4 0		8 59	0014	088			s	s	s
2935	Hart s Ranch 19 m S Tucson	10 15 02		33 8	2 0		2 12	0066	068			v s	s	v s
1744	Tucson City Supply	6 20 97		47 5										
2141	Tucson City Supply, 4 W well	5 1 99		44 3	3 95			f						
2142	Tucson City Supply 3 E wells	5 1 99		35 4	2 60			f						
2844	City Supply Tucson	5 15 02		38 6	4 0			v f	084			s	f	f
2988	City Supply Tucson	3 12 03		37 4	3 2			f	038	f	0088	s	f	s
1899	Carillo s Gardens Tucson	3 27 98		76 5								v s	n	s
1742	Natatorium Tucson	6 20 97		135 0										
1931	Natatorium Tucson	6 15 98		146 5	19 0							s	f	v s
2145	S P Depot Tucson	5 16 99		45 0	4 3									
2858	Cold Storage Co , Tucson	5 21 00	350	35 8	3 5		1 48	n	073			9 42	0 29	3 46
2967	Cold Storage Co , Tucson	3 12 03	350	38 4	4 9		3 19	n	02	0041	0066	s	f	f
2519	Electric Light Co Tucson	10 29 00	215	43 9	7 3							s	s	s
2986	Electric Light Co Tucson	3 12 03	215	36 1	4 0			n	f	002	008	s	f	f
2601	Tucson Milling Co	4 8 01	63	43 2	3 2	8 9		f	042			v s	f	s
2841	Manning s Well Tucson	5 2-02		94 6	8 4			f	16			v s	s	s
2843	C I Hoff Brockman s Add Tucson	5 10-02		49 6	4 92	6 53			10			s	f	f
2964	J S Mann Tucson	12 23 02		36 2	2 7	4 45								
3136	New Well of S P R R Tucson	5 2 03	46	45 6	4 6	9 2						s	f	s
2815	Perry Williams Maricopa	4 19 02	35	160 0	50 0	24 48		f	20			v s	v s	s
2816	R R Co s Well 1½ W Maricopa	4 19-02		39 8	6 4	5 41		v f	104			s	s	f

* f faint v f very faint s strong v s very strong sl slight n none pr pronounced

TABLE II—RILLITO UNDERFLOW.

No.	LOCATION Arranged in order going down Rillito Valley	DATE	Depth	Parts in 100,000								QUALITATIVE		
				Total Soluble Solids @ 110° C	Chlorides, Na Cl (Common Salt)	Hardness, Ca So_4 (Sulphate of Lime)	Alka'inity, Na_2 Co_3 (Black Alkali)	*Nitrogen, in the form of Nitrites	*Nitrogen, in the form of Nitrates	Ammonia, Free	Ammonia. Albuminoid	*Sulphates	†Magnesia	†Lime
2983	Empire Ranch in Cienega	9-15-02	......	40.0	2.6	......	9.54	s.	s.	......	......	s.	v.s.	s.
2934	Well W. slope Rincons	9-15-02	......	86.6	4.8	16.59	......	.002	.20	......	......	v.s.	v.s.	v.s.
2777	Agua Caliente, 17 m. E. of Tucson	12-26 01	......	52.0	5.56	......	7.42	n.	.035	......	......	v.s.	sl.	pr.
1491	Sahuara Spring, Gibbon's Ranch	10-29-96	......	33.4	s.	......	s.	......	......	......	......	......	......	......
2948	Sahuara Spring, Gibbon's Ranch	10-19-02	......	27.8	2.0	......	10.80	v.f.	f.	......	......	s.	n.	v.f.
2138	Sabino Canyon Stream	4-15-99	......	5.5	.6	......	sl.		......	......	......	......	......	......
2947	Sabino Canyon Underflow	10-19-02	......	11.6	1.6	......	2.75	v.f.	f.	......	......	f.	n.	f.
246	Ft. Lowell	5-14-92	......	16.0	1.5	......	......	......	......	......	......	......	......	......
2812	R. H. Cole, Ft. Lowell	6-26-02	......	34.0	2.20	......	2.96	n.	.283	......	......	pr.	f.	pr.
2946	Cole's Underflow Well	10-19-02	......	11.2	1.6	......	1.06	.003	f.	......	......	f.	n.	f.
189	Ranch 2 m. N. University	3-13-92	......	24.5	1.4	......	......	......	......	......	......	......	......	......
249	L. M. Price, 4 m. N. Tucson	5-18-92	......	25.0	2.8	......	......	......	......	......	......	......	......	......
195	University	4-6-92	90	26.0	3.0	......	......	......	......	......	......	......	......	......
642	University	11-11 92	90	27.0	3.8	......	......	......	......	......	......	......	......	......
1743	University	9-20 97	90	25.9	......	......	......	......	......	......	......	......	......	......
2817	University	3-3 02	90	24.8	2.05	......	3.50	n.	.15	......	......	s.	s.	f.
2751	R. H. Forbes well	10-24-01	90	25.1	2.06	......	2.44	v.f.	.176	.002	.0024	s.	f.	s.
2690	Mrs. Norway	1-26-01	85	28.8	2.90	......	1.69	s.	.14	......	......	s.	pr.	s.
248	Indian School, Tucson	5-10-92	85	29.0	1.5	......	......	......	......	......	......	......	......	......

* f., faint; v. f.; very faint; s., strong; v. s., very strong; sl., slight; n., none; pr., pronounced.

TABLE III—ARTESIAN WELLS.

No	ARTESIAN WELLS	DATE	Depth	Parts in 100,000								QUALITATIVE		
				Total Soluble Solids @ 110° C	Chlorides, Na Cl Common Salt)	Hardness Ca So_4 Sulphate of Lime	Alkalinity Na, Co_3 (Black Alkali)	*Nitrogen in the form of Nitrites	*Nitrogen in the form of Nitrates	Ammonia, Free	Ammonia Albuminoid	Sulphates	Magnesia	*Lime
2212	O F Ashburn, St David	10 9 99	450	16 0	1 1		7 5					f	f	f
2214	H M Eckerman, St David	10 19 99		25 2	1 2		6 1					f	n	s
2185	J Blake, Safford	4 11-99		56 0	22 3		5 01							
2258	Mud Spring, Safford	1 8 00	310	103 0	19 9		19 4					s	n	n
2270	Mud Spring, Safford	1 25 00	310	99 6	51 7		19 6					v s	v f	n
2271	Clarson's Well Safford	1 25 00	807	79 6	44 8		2 4					s	f	f
2272	Hildreth's Well, Safford	1 26 00	80	57 8	22 3		3 4					s	f	f
2374	J W Lee, Safford	7 4 00		46 2	18 0		1 9	f	0114			9 21	0 22	0 66
2511	M A Cluff, Safford	10 20 00	312	110 6	62 0		5 51					21 0	0 36	2 33
2512	M A Cluff, Safford	10 21 00	627	211 6	130 0		7 20					37 1	0 24	9 32
2557	W D French Safford	12 4 00	120	15 9	2 0		9 32					f	n.	f
2704	W Gibson, Benson	8 15 01	840	98 4	3 0	20 1		0 03	s			v s	f	s

* f, faint, v, f, very faint, s strong, v s very strong sl slight n, none pr pronounced

TABLE IV—SALT RIVER VALLEY UNDERFLOW

				Parts in 100 000								Qualitative		
No	LOCATION	DATE	Depth	Total Soluble Solids @ 110° C	Chlorides *Na Cl (Common Salt)	Hardness ‡Ca So$_4$ Sulphate of Lime	Alkalinity Na$_2$ Co$_3$ (Black Alkali)	*Nitrogen in the form of Nitrites	*Nitrogen in the form of Nitrates	Ammonia Free	Ammonia Albuminoid	*Sulphates	*Magnesia	*Lime
	ALHAMBRA													
2082	Alhambra town well	9 16 98	50	116.3	56 0		34 13		05					
2083	A H Smith	9 16 98	95	130 5	40 0	s		012	10 0					
2084	D D Crabb	9 16-98		41 1	10 0	s		0004	1 5					
2085	Barkley	9 16 98	90	340 8	68 0	s		0084	16 0					
	GLENDALE													
2086	Boyer	9 16 98	80	234 5	149 0	s			60					
2087	W S McClain	9 16 98	80	117 6	29 0	s		016	7 0					
2088	Town Well	9 16 98	90	79 2	39 0	s		0003						
2089	Bartlett	9 16 98	140	53 1	17 0	s			80					
3090	Mosher	9 16 98	70	346 4	112 0	v s			1 00					
2091	J B Morgan	9 16 98	40	46 2	10 0	s		0028	40					
2150	B A Fowler	6 30 99		80 9	13 2	36 5								
2619	W J Murphy	6 8 01		115 8	35 6	46 11						v s	v s	v s
2620	J B Doner	6-8 01		143 6	44 8	53 2						v s	v s	v s
2621	H B Lehman	6 8 01		91 2	30 8	35 8						s	v s	s
2622	A J Straw	6 8 01		188 6	81 0									
2623	A W Bennet	6 8 01		31 0	5 6		32					f	f	f
2624	E E Jack	6 8 01		57 9	9 6		4 35					pt	f	pr
	MESA													
1506	H L Chandler	11 24 96		103 6	v s							s		
1515	A J Chandler	2 1 97		166 6	v s							f		f
1517	A J Chandler	2 1 97		179 4	v s							s		s
2422	Spring in Superstition Mts	7 12-00		171 4	8 6	52 6						v s	s	v s
2615	McQueen Ranch	5 17-01	1305	133 2	82 0	11 15		0067	43			v s	v s	v s
2724	A J Chandler Sec 22 1S 5E	8 27 01	150	174 2	110 7	47 02		s t	07			s	v s	s
2775	A J Chandler, Sec 22, 1S , 5E	12 5 01		176 2	111 1	42 6		n	02			v s	v s	v s
2804	A J Chandler N E ¼ Sec 27 1S , 5E	1 28 02	54	108 2	48 8		7 68	0094	21			s	f	f
2818	A J Chandler, Sec 22 1S , 5E	3 9 02	705	157 4	104 0	80 3		v f	12			v s	v s	v s
2819	A J Chandler, Sec 22 1S , 5E	3 9 02	146	172 2	110 0	45 3		v f	12			v s	v s	v s
2820	A J Chandler, Sec 22, 1S , 5E	3 9 02	236	163 8	104 4	44 5		v f	12			v s	v s	v s
2977	A J Chandler, Sec 22 1S , 5E	2 6 03	240	299 6	154 8	20 0		0107	29			v s	s	v
2988	A J Chandler N W ¼ Sec 34 1S 5E	3 7 03	280	162 4	80 4	52 2		0061	27			v s	s	v s

TABLE IV—CONTINUED

No	LOCATION	DATE	Depth	Parts in 100 000								QUALITATIVE		
				Total Soluble Solids @ 110° C	Chlorides, *Na Cl (Common Salt)	Hardness *Ca So_4 (Sulphate of Lime	Alkalinity Na_2 Co_3 (Black Alkali)	*Nitrogen in the form of Nitrites	*Nitrogen in the form of Nitrates	*Ammonia Free	Ammonia Albuminoid	*Sulphates	*Magnesia	*Lime
3138	Desert Well Sec 11 1S 7E	5 14 03	212	32 0	5 2		4 66	v f	49			f	v f	f
3141	E Olsen, Sec 18 1S, 5E	5 14-03	212	381 0	235 2	59 8		f	2 00			v s	s	v s
3144	P Metz	5 14-03	56	107 8	108 0		9 33	v f	38			s	f	s
3145	Alhambra Hotel	5 14 03	51	152 0	89 6		5 51	v f	33			s	f	s
3146	Dorman Bros, Sec 33 1N, 6E	5 14 03	100	114 0	74 0							s	v f	s
3157	A J Chandler S W ¼ Sec 22 1S 5E	6 13 03		127 4	75 6	23 1		f	07			s	f	pr
3158	A J Chandler N W ¼ Sec 22 1S 5F	6 13 03		84 8	44 6	18 5		f	26			s	f	s
	PHOENIX													
1819	Fowler Bros	4 30-97		399 3	v s							v s	s	f
2017	Mrs W J Murphy	8 15 98		334 3	107 0			05	10 00	011	016	34 3	3 64	10 5
2067	N Centre Ave	9 15 98		117 7	66 5			n	20					
2068	School Bldg Centre Ave	9 15-98		216 1	150 0				20					
2069	Indian School	9 15 98	15	222 0	141 0		33 36	0008	f					
2070	Indian School	9 15-98	60	362 3	258 0	s		0029	30					
2071	Lawrence near Indian School	9 15 98	30	413 1	285 0	s			00					
2072	Near Indian School	9-15-98	24	270 8	176 5		23 6	0008	30					
2073	Cawthorn	9 15 98	65	97 6	61 0	s		0006	40					
2074	Orangewood	9-15 98	105	44 9	16 0	s		0016	80					
2075	Weeder	9 15 98	146	76 1	31 5	s		0076	70					
2076	Beshler	9-15-98	36	126 9	43 0		39 2		10					
2077	Churchill	9-15 98	92	284 6	103 0	s		0004	80					
2078	Churchill	9 15 98	70	531 8	179 5	s		048	2 10					
2079	M Morrison	9-15-98	28	287 5	203 0	s		0002	80					
2080	Christie	9 15 98	22	150 6	84 0	s			05					
2081	G R Brewster	9-15 98	35	122 5	44 5		33 64	0004	40					
2095	Phoenix City Supply	9 18 98		116 8	72 5	s		0007	10					
2840	Phoenix City Supply	6-9 02		102 4	54 6	8 98		0045	16			v s	v s	v s
3139	Phoenix City Supply Drilled Well	5 14 03	208	132 0	77 6	5 4		v f	25			pr	pr	s
3140	Phoenix City Supply, Dug Well	5-14-03	42	130 0	80 8	6 5		021	25			pr	pr	s
2119	N 4th Ave	12 2 98		130 7	78 5	s		0136	05					
2148	G R Brewster	8 30 99		103 4	30 5		34 87	0006	02					
2215	Dr Duffield	10 24 99		75 1	35 0		2 3					s	n	f

TABLE IV—CONTINUED.

No.	LOCATION	DATE	Depth	Parts in 100,000								QUALITATIVE		
				Total Soluble Solids @ 110° C	Chlorides, *Na Cl (Common Salt)	Hardness, *Ca So$_4$ (Sulphate of Lime)	Alkalinity, Na$_2$ Co$_3$ (Black Alkali)	†Nitrogen, in the form of Nitrites	*Nitrogen, in the form of Nitrates	†Ammonia, Free	Ammonia, Albuminoid	*Sulphates	*Magnesia	*Lime
2216	Dr. Duffield	10-24-99	......	68.8	32.0	......	4.3	......	......	......	......	......	......	......
2421	Indian Springs Outing Club	7-12-00	......	22.6	2.6	1.9	......	......	......	.0062	.0077	f.	f.	f.
2522	McDowell Range	10-30-00	......	25.6	5.0	3.0	......	n.	.29	......	......	......	......	......
2612	L. W. Perkins	5-10 01	......	83.6	30.8	8.8	......	.0871	.53	......	......	v.s.	s.	s.
2625	W. J. Murphy, 7N, Phoenix	6-8-01	......	28.2	3.1	......	2.12	......	......	......	......	f.	pr.	f.
2696	W. J. Murphy, 7N, Phoenix	7-3 01	......	27.6	3.1	......	2.44	f.	.47	......	......	v.f.	f.	f.
2774	B. Smith near Indian School	10-14 01	25	235.8	153.5	12.10	......	.0029	.31	......	......	v.s.	v.s.	v.s.
2837	Thos. Murphy, Sec. 30 2N., 4E.	4-22-02	187	380 4	140.0	10.88	......	.40	2.33	......	......	v.s.	v.s.	v.s.
2838	Thos. Murphy, Sec. 30, 2N., 4E.	4-22 02	168	303.2	136.0	26.65	......	.80	2.70	......	......	v.s.	v.s.	v.s.
2839	Thos. Murphy, Sec. 30, 2N., 4E.	4-22-02	78	388.0	105.0	......	45.16	.0666	1.43	......	......	v.s.	v.s.	v.s.
2842	Thos. Murphy, Sec. 30, 2N., 4E.	5-9-02	325	325.8	123.4	32.1	......	.0078	.06	......	......	v.s.	v.s.	v.s.
2845	J. Miller	5 27-02	......	239.0	89.8	......	......	......	......	......	......	v.s.	v.s.	v.s.
2849	Asylum	6-12-02	42	120.4	79.2	8.2	......	f.	f.	......	......	v.s.	v.s.	v.s.
2949	Asylum	10-31-02	90	126.4	78.8	13.6	......	v.f.	v.f.	......	......	v.s.	s.	s.
2960	Soap Springs 50 m, N. Phoenix	1-5-03	......	272.2	52.4	......	144.6	......	......	......	......	s.	f.	f.
2970	A. C. Bartlett, Sec. 32, 2N., 3E.	1-2-03	60	184.0	102.8	6.8	......	f.	.66	......	......	v.s.	v.s.	s.
2981	Indian School	3-7-03	45	245.2	160.8	31.8	......	f.	.40	......	......	v.s.	v.s.	v.s.
2982	Indian School	3-7-03	145	250.0	145.6	65.8	......	.004	.25	......	......	v.s.	v.s.	v.s
3142	J. J. Harris, Sec. 6, 1N., 2E.	5-14-03	108	268.0	185.0	84.8	......	v.f.	2.00	......	......	s.	s.	v.s.
3143	H. Thompson, Sec. 8, 3N., 3E.	5 14-03	104	26.0	4.0	......	4.88	.126	.33	......	......	f.	v.f.	v.f.
	SCOTTSDALE													
2092	H. L. Underhill	9 17-98	61	84.4	50.0	s.	......	......	.15	......	......	......	......	......
2093	Geo. Blount	9-17 98	40	159.4	90.0	......	......	......	.40	......	......	......	......	......
2785	Winfield Scott	1-9-02	......	167.4	100.8	42.7	......	.001	.50	......	......	v.s.	v.s.	v.s.
2786	Paradise Valley	1-9-02	......	25.6	5.72	1.6	......	.0049	.35	......	......	f.	pr.	pr.
2961	Winfield Scott	12-5-02	60	171.4	91.2	21.22	......	......	......	......	......	v.s.	v.s.	s.
	TEMPE													
1525	J. W. Johnson	3-15-97	11	79.2	s.	......	......	......	......	......	......	f.	......	......
2110	Hough's Creamery	12-2-98	......	103.0	67.0	s.	......	......	......	......	......	......	......	......
2111	Hough's Ranch	12-2-98	8	188.5	109.0	s.	......	.0004	.30	......	......	......	......	......
2113	Woolf's Ranch	12-2-98	15	160.0	94.0	s.	......	.0012	.20	......	......	......	......	......
2114	J. B. Mullen	12-2-98	13	287.6	192.0	s.	......	.0004	.25	......	......	......	......	......

TABLE IV—CONTINUED.

No.	LOCATION	DATE	Depth	Parts in 100,000								QUALITATIVE		
				Total Soluble Solids @ 110° C	Chlorides, *Na Cl (Common Salt)	Hardness, *Ca So, (Sulphate of Lime	Alkalinity, Na_2 Co_3 (Black Alkali)	*Nitrogen, in the form of Nitrites	*Nitrogen, in the form of Nitrates	*Ammonia, Free	Ammonia Albuminoid	*Sulphates	*Magnesia	*Lime
2115	W. T. Fowler	12-2-98	12	169.1	88.5	......	26.82	.0028	.30	.. ..	...	....	....	...
2116	Nils Peterson	12-2-98	20	221.8	141.5	......	24.91	.0004	.20	..	.	.. .	..	
2118	A. P. McKeons	12-2-98	......	171.5	110.0	6.8	... .	.0004	.05	. . .	. .	.	. . .	. .
2303	Woolf & Jones	3-28-00	......	128.8	80.8	12.0	.. ...	.0096	.30	.. ..	. . .	. .	. ...	
2304	Woolf & Jones	3-28-00	. ..	190.4	120.0	6.1	.	......	.25	......	......	......	......	......
2389	Hotel Casa Loma	5-7-00	......	169.8	105.8	12.9	...	.0027	.18	.0048	.0036	v.s.	pr.	v.s.
2748	Geo. Kinney	10-17-01	40	202.0	180.5	8.16	......	n.	.25	v.f.	.0087	s.	v.s.	s.
2766	Normal School	11-19-01	80	219.2	133.6	15.78	......	n.	.51	.0027	.0156	v.s.	v.s.	v.s.
2966	Jenkin's Well, Sec. 20, 1N., 4E	1-2-03	50	217.0	142.4	. . .	3.6	.004	.20	....	. .	v.s.	s.	s.
2967	Jenkin's Well, Sec. 20, 1N., 4E	1-2-03	50	223.0	141.2	......	3.4	......	......	. . .	... .	v.s.	s.	s.
2968	Hansen Well, Sec. 35, 1S., 4E	1-2-03	156	509.0	355.0	60.9	......	......	......	.. ..	.. ...	v.s.	v.s.	v s.
2969	H. L. Chandler, Sec. 21, 1N., 4E.	1-2-03	180	224.0	146.0	......	2.12	... ..	......	......	......	v.s.	v.s.	s.
2978	Tempe City Supply	1-3-03	200	103.0	58.8	9.52	.....	n.	.17	.0028	.0068	s.	s.	s.
2980	Hansen Well, Sec. 35 1S., 4E	3-2-03	156	446.8	307.0	195.4	. .	f.	f.	. ....	.. ..	v.s.	v.s.	v.s.
3118	Judson Well	3-19-03	200	115.2	78.6	11.4	.	. .	.. ...	. .	..	s.	pr.	s.
3119	Judson Well	3-19-03	300	155.8	105.4	21 8	. . .	.	......	. .	.. ..	s.	pr.	s.

* f., faint; v. f., very faint; s., strong; v. s. very strong; sl., slight; n. none; pr., pronounced.

TABLE V—MISCELLANEOUS.

No.	MISCELLANEOUS	DATE	Depth	Parts in 100,000								QUALITATIVE		
				Total Soluble Solids @ 110° C	Chlorides, Na Cl (Common Salt)	Hardness, Ca So$_4$ (Sulphate of Lime)	Alkalininy, Na$_2$ Co$_3$ (Black Alkali)	Nitrogen, in the form of Nitrites	*Nitrogen, in the form of Nitrates	Ammonia, Free	Ammonia, Albuminoid	†Sulphates	‖Magnesia	†Lime
187	O. F. Townsend, Yuma	3-5-92	......	72.5	23.4	......	19.0	......	......	......	......	......	......	......
189	A. Borseng, Yuma	8-5-92	......	217.5	32.5	......	2.0	......	......	......	......	......	......	......
266	Yuma	......	......	76.0	22.0	......	.0	......	......	......	......	......	......	......
864	Townsend, Yuma	......	......	397.0	264.0	......	1.0	......	......	......	......	......	......	......
988	Baker's, Yuma	......	......	139.0	68.0	......	6.7	......	......	......	......	......	......	......
2144	Catalina Mts., Tucson	5-15-99	......	94.3	16.0	......	......	......	......	......	......	......	......	......
2146	Cadwell & Swatting, Wilcox	5-30-99	270	32.8	5.5	......	16.5	......	......	......	......	s.	......	n.
2226	Salt River, Tempe	11-17-99	......	134.5	81.8	......	......	.04	.10	.0074	.0102	......	......	......
2235	San Jose Ditch Solomonsville	12-2-99	......	60.0	28.0	......	......	......	......	......	......	s.	f.	s.
2251	Jenkin's Ditch, near Tempe	12-26-99	......	189.4	136.0	......	8.4	......	......	......	......	v.s.	s.	v.s.
2252	Jenkin's Ditch, near Tempe	12-26-99	......	216.4	142.9	......	7.7	......	......	......	......	s.	s.	s.
2255	Gila River, Safford	1-8-00	......	51.5	28.3	......	2,54	......	......	......	......	s.	f.	s.
2268	W. M. Ward's ditch-water cistern	2-6-00	......	101.0	65.6	......	......	f.	.08	.0163	.0105	......	......	......
2283	Gila River at Gila Bend	8-5-00	......	151.6	97.2	17.9	......	.002	.08	......	......	v.s.	s.	v.s.
2284	Well near Buckeye	8-5-00	......	153.6	72.8	25.5	......	s.	.35	......	......	v.s.	s.	v.s.
2285	Buckeye Canal	3-5-00	......	182.0	119.2	23.1	......	.0032	.126	......	......	v.s.	s.	v.s.
2286	Richardson's Ditch, Agua Fria	8-5-00	......	30.0	6.0	......	1.17	.004	.16	......	......	s.	s.	s.
2287	Salt River Seepage, Phoenix	3-5-00	......	130.0	86.4	......	.32	.0064	.30	......	......	s.	s.	v.s.
2288	Salt River at Tempe	3-5-00	......	118.0	79.8	10.2	......	.008	.22	......	......	s.	s.	v.s.
2289	Salt River at Arizona Dam	3-5-00	......	102.2	68.4	.62	......	......	.20	......	......	s.	s.	s.
2293	Agua Fria Underflow, Buckeye	3-6-00	......	78.4	82.2	1.50	......	f.	.08	......	......	......	......	......
2294	City Supply, Prescott	3-10-00	......	39.4	11.0	6.9	......	.004	.555	.0205	.0048	s.	f.	s.
2340	Richardson's Ditch	5-21-00	......	33.4	7.4	......	1.3	f.	.148	......	......	s.	s.	s.
2341	Buckeye Canal	5-21-00	......	185.0	121.8	23.4	......	f.	.165	......	......	v.s.	v.s.	v.s.
2342	Santa Cruz River, Calabasas	5-21-00	......	29.6	5.8	......	......	n.	.067	......	......	s.	f.	s.
2343	Sonoita River	5-21-00	......	63.0	3.4	25.3	......	n.	.048	......	......	v.s.	s.	v.s.
2366	Haskell & Herwagen, Jerome	5-30-00	......	33.8	1.7	1.2	......	n.	.042	......	......	s.	f.	s.
2367	Haskell & Herwagen, Jerome	5-30-00	......	34.4	1.5	.7	......	n.	.028	......	......	s.	f.	s.
2570	Agua Caliente, Gila Bend	1-28-01	......	70.8	34.0	......	4.03	n.	f.	......	......	s.	v.f.	f.
2589	Bate's Spring, Dudleyville	2-25-01	......	101.0	10.0	6.8	......	......	......	......	......	s.	s.	s.
2606	Cluff's Ranch, Pima	5-1-01	......	24.6	2.7	......	1.5	n.	f.	......	......	f.	v.f.	s.

TABLE V—CONTINUED

No	MISCELLANEOUS	DATE	Depth	Parts in 100 000								QUALITATIVE		
				Total Soluble Solids @ 110° C	Chlorides Na Cl (Common Salt)	Hardness Ca So₄ (Sulphate of Lime)	Alkalinity Na₂ Co₃ (Black Alkali)	*Nitrogen in the form of Nitrites	*Nitrogen in the form of Nitrates	Ammonia Free	Ammonia Albuminoid	*Sulphates	Magnesia	*Lime
2618	W J Trevorrow Somerton	5 21 01		420 0	164 0							v s	s	f
2629	Dr Aston Wilcox	6 22 01		24 8	3 0		10 7	v f	f			v f	f	f
2649	Indian Hot Springs, Ft Thomas	12 15-01		288 8	227 2	16 4		002	s			v s	s	v s
2678	H. E Kell Buckeye	7 20 01		741 8	469 5	63 0		s	072			v s	v s	v s
2780	Santa Cruz Flood Water, Tucson	8 19 01		28 3	1 5		6 47		0392			s	f	s
2781	Chevelon Creek Winslow	8 1 01		243 2	195 2	10 7			07			v s	s	s
2792	Krentz & Wolff, Winslow			213 6	140 8	3 1			053			v s	s	s
2733	Sunset Water Winslow			411 0	339 7	24 4			05			v s	v s	v s
2734	Sorens Dragoon Mts	9 5 01		160 1	17 6	61 6		001	4 629			s	v s	s
2738	J J Roth Cochise	10 14 01		51 6	4 8	13 2		f	s					
2740	Dr Scroggs Octave	10 8 01		36 2	2 0			n	042			f	s	s
2741	Dr Scroggs Octave	10 8-01		35 0	2 0			n	038			f	s	s
2767	Clear Creek Ditch Winslow	11 21 01		128 7	95 3		5 1	002	s			v s	s	s
2768	St Josephs Ditch Winslow	11 21 01		111 4	56 5	15 2			s			v s	s	v s
2769	St Josephs Ditch Winslow	11 21 01		70 3	29 3	6 8			035			v s	s	s
2803	D M Potter, Clifton	1 22 02		1156	1053 0	63 7		0112	f			s	v s	v s
2806	S Merrill Cochise	2 11-02		21 2	3 2		3 18	0038	162			s	f	s
2909	M Lyall Yuma	7 16 02		312 6	183 4	56 0		f	f			v s	v s	v s
2923	Allison's Ditch, Tucson	7 30 02		75 3	8 2		2 23	v s	1			s	s	s
2924	Chevelon Ditch Winslow	7 25-02		244 9	208 8	4 5		n	f			s	v s	s
2925	Chevelon Ditch, Winslow	7 25-02		321 2	274 8	5 3		f	f			s	v s	s
2926	Chas Gaume, Safford	7 25 02		79 7	31 4		18 1	s	n			f	n	f
2927	Chas Gaume, Safford	7 25-02		349 2	190 2		2 4	f	f			v s	f	f
2985	8 C Ranch, Oracle	3 9-03		40 0	1 8		4 9	0016	03			f	f	s
3120	Canyon del Oro Tucson	3 24 03		16 0	2 6		sl	f	0224			v f	f	f
3121	Park s Ranch Graham Co	3 27 03		103 0	32 4		16 1	004	f			v s	n	v f
3131	N C Nelson Palomas	4 13 03		258 8	162 6	39 3		0082	12			v s	v s	v s
3132	N C Nelson, Palomas	4 19 03		578 6	885 0	134 4		0032	18			v s	v s	v s
3147	F L Ewing, Yuma	5 6-03	84	62 6	17 2		23 5	n	v f	002	009	s	s	s
3154	C T Sharp Sacaton	5 20 03	30	132 6	66 8	29 4		031	089			v s	s	v s
3162	D K Udall, Hunt Apache Co	6 25-03		20300	18700									

*f faint v f very faint s strong v s very strong sl slight n none pr pronounced