

*T. M. Leonard*

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ARIZONA AGRICULTURAL  
EXPERIMENT STATION.

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Bulletin No. 4, November, 1891.

TUCSON, ARIZ.

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"Waters and Water Analysis."

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CITIZEN

# Agricultural Experiment Station.

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# WATERS AND WATER ANALYSIS.

## INTRODUCTION.

The object of this bulletin is to explain the terms used in a chemical analysis of water and to put before the people of the Territory some of the work which has been done preliminary to a complete examination of the waters of Arizona. It is not designed for chemists but to familiarize the general public with the technical terms necessarily used in giving data of water analyses. Some of the chemical problems peculiar to our characteristic waters will be published later in another form.

If the Bulletin succeeds in awakening an interest in the character of the waters and their effects on soils the Station will be contented.

The Chemical Laboratory of the Agricultural Experiment Station has been equipped for the purpose of investigating the agricultural resources of Arizona. We invite correspondence in regard to chemical problems connected with water supply, soils and soil deposits, waste materials and fertilizers and the canning or drying of fruits. Any plant or substance likely to be of value to the agricultural interests of the Territory will be analyzed free of charge, if a sample is forwarded to the Station. The Station reserves the right to use and publish in the interests of the Territory any results so obtained. Before sending a sample it would be well to put yourself in correspondence with the Station, as we may be able to save time and trouble and can give you specific directions applicable to sampling in that particular case.

All correspondence should be addressed to the

AGRICULTURAL EXPERIMENT STATION,

University of Arizona,

*For the Chemist*

TUCSON ARIZONA.

## DIRECTIONS FOR SAMPLING WATERS.

Water is such an important factor in the development of the Territory, and its analysis helps to solve so many practical problems that this work by the Agricultural Experiment Station is deemed of great importance. To make these analyses of the greatest value it is necessary that we have a large number of samples from all parts of the Territory, and that in collecting the sample every precaution be observed against outside contamination.

*Quantity Needed.*—Not less than one gallon or four wine bottles full should be sent, and if a complete analysis is desired, as for irrigation, effect on boilers or use in towns, not less than two gallons should be sent.

*Vessels to be Used.*—Place all samples in glass bottles or demi-johns, never in earthen jugs or tin cans. If the glass vessel is not new it should be thoroughly cleaned by shaking violently with a handful of coarse sand and a small amount of water, after which the vessel should be rinsed several times. Often a thin deposit has settled on the inside of the vessel which can be removed only by persistent effort.

It is at once apparent that an unclean vessel would render the analysis worthless. The corks if not new should be boiled in water before being used.

*Method of Taking Sample.*—Water, in all cases, should be taken directly from the well, spring or stream when sampled. Do not fill the vessel until it has been rinsed with the water to be sampled. When the vessel is almost full insert the cork, cut it off even with the edge and cover with sealing wax or beeswax. If a gas escapes from the spring, a sample should be taken by inverting a bottle filled with water over the bubbles and allowing the gas to replace the water. This bottle should be corked under water and carefully sealed.

*Marking and Sending Sample.*—Every sample should be plainly and carefully marked and accompanied by a full statement of locality, source of water, depth of well, or flow of spring or stream, and a sample of efflorescence if any is caused by the water. If rain has

recently increased the volume or drouth decreased it, this fact should be stated. It is also important that as far as possible a description of the nature of the rocks and soils be given. Any facts concerning the nature or characteristics of the water will be of value. In case of warm springs the temperature should be given.

Water sampled according to these directions will be analyzed free of charge.

Forward all packages by express, charges prepaid, to :

AGRICULTURAL EXPERIMENT STATION,

University of Arizona,

*For the Chemist.*

TUCSON, ARIZONA.

### WATER ANALYSIS.

Waters generally partake of the nature of the surrounding soil, and purity in waters is a comparative term. It is difficult for the Chemist to prepare absolutely pure water and such water is never found in the usual sources of water supply. Water is a universal solvent and dissolves something from all substances with which it comes in contact.

*Rain Water* —No natural water is so nearly pure as rain water, which however contains gases and particles of dust in solution. Rain water has various degrees of purity; that collected in cities and towns at the beginning of a shower being most impure. Rain water often becomes very impure before reaching the cistern from contaminations on the roof or in the conductors. In this way too, the cistern may become so foul that the water is unfit to drink.

*Ground Water.*—Water which flows over lime rocks, beds of salt or alkaline deposits is most heavily charged with mineral matter. In regions where the rocks are composed of granite or quartz, which are only slightly soluble, the water may contain as little as one part of solid matter to one hundred thousand of water. Sea water has about 3840 parts of solid matter to one hundred thousand of water. Between these two extremes there are varying amounts of solids in solution.

*Organic Contamination* —Water which comes in contact with

decaying animal or vegetable matter is most heavily charged with nitrogenous matter and such water is unfit to drink. Such waters are most dangerous for they are often perfectly clear and neither taste or smell can detect the impurity.

*Importance of Water Analysis.*—The subject of water supply is of great importance but at the same time that the farmer considers the subject of supply he should know something of its quality. In countries where the rainfall is too light to wash the soluble salts from the soil and where irrigation is practiced there is a constant accumulation in the soil. The process of evaporation brings most of these salts near the surface where they do most damage. If more soluble salts are added and none leached out, there is after a time such an accumulation as to prevent vegetable growth. Experience in India has shown that where the water used for irrigation is heavily charged with soluble matter, the soil in the course of years becomes so heavily impregnated with these salts that it will no longer support vegetation.

The experience in some parts of California has been the same. If the characteristics of the water are known in the beginning and proper methods of leaching and neutralization are used no such results need occur.

*Matter in Suspension.*—Some river waters are turbid and only slowly settle clear. It does not necessarily follow that such water is unfit for use, even before it is perfectly clear. The fact that some cities use water which is not perfectly clear cannot definitely be said to affect the public health. Larger particles of sand soon settle and water flowing over sandy soil is usually clear. Turbidity is generally caused by finely divided particles of clay which settle completely only after several days. The cheapest method of treating such waters is that usually adopted, of having several cisterns or tanks and allowing the water to stand undisturbed at least 48 hours.

If turbid water is passed through a good filter it will become perfectly clear. This is often done but on a large scale is somewhat expensive. In any case unless the filters are frequently and perfectly cleaned it gives a semblance of purity which does not exist. If a

filter becomes foul it may make the water clear but leave nearly all the organic impurity.

*Matter in Suspension* is the weight of solid matter which a measured quantity of water would leave on the filter.

*Matter in Solution*.—Water may be clear and still carry considerable solid matter in solution. This is shown by incrustations on boilers, tea-kettles and ollas, but *it is a mistake to suppose that all white deposits from waters are alkali*. Alkaline substances have the property of combining with organic matter to form so called "black alkali," which is true alkali. The so called "white alkali" is more frequently common salt, or mixtures of salt, lime, and sometimes borax, which are not alkali.

*Composition of Matter in Solution*.—The substances most commonly found dissolved in water are soda and potash salts, lime and magnesium salts, iron, silica, and alumina.

These substances are present in such small quantities that they cannot conveniently be represented in the usual method of percentage.

In reports from this Station the salts will be given in parts per 100,000. It is evident at a glance just what it means. If we speak of water containing 20 parts per 100,000, it means that if 100,000 pounds of water were evaporated it would leave 20 pounds of solid matter.

#### STATEMENT OF RESULTS.

A chemical analysis of water may be qualitative or quantitative. A *qualitative* analysis shows the character of the substances present. If the amount of any salt present is determined it is called a *quantitative* analysis. This is much more expensive and is not always necessary. The character of the analysis will depend on the purpose for which the water is to be used. In cases where the importance of the subject is sufficient a complete quantitative analysis will be made.

The result of the analysis may be recorded either as oxides of the metals or as salts of the metals. In case the oxides of the

metals are given they represent the exact amount of these elements present combined with oxygen. The elements are found in waters combined with chlorine as *chlorides*, with sulphur and oxygen as *sulphates* or with carbon and oxygen as *carbonates*. The exact combination cannot in most cases be determined and when the result is recorded as salts—chlorides, sulphates and carbonates—these salts represent the combinations which probably exist in the water. The University water is, for illustration, recorded below in both forms:

## AS OXIDES OF THE METALS.

	PARTS PER 100,000
Total Solids.....	25.00
Sodium Oxide.....	4.20
Potassium Oxide.....	0.30
Calcium Oxide.....	5.10
Magnesium Oxide.....	1.10
Sulphuric Anhydride.....	3.20
Silicon Oxide.....	2.00
Carbonic Oxide.....	5.75
Chlorine.....	1.18

## AS SALTS OF THE METALS.

Total Solids.....	25.00
Sodium Chloride.....	1.53
Potassium Chloride.....	0.50
Sodium Silicate.....	4.00
Sodium Sulphate.....	3.20
Calcium Sulphate.....	2.38
Calcium Carbonate.....	7.32
Magnesium Carbonate.....	3.50

## EXPLANATION OF TERMS USED IN WATER ANALYSIS.

*Total Solids* is the term used to designate the amount of solid matter obtained when a known quantity of water is evaporated. It is the amount of residue left in the soil by evaporation. If the total solids be again placed in water a certain part will resist solution.

The insoluble part consists of silica, iron, carbonates of lime and magnesia, and part of the sulphate of lime. This portion is

termed *Residue Insoluble After Evaporation*. The soluble part consists of the soda and potash salts, sulphate of magnesia and part of the sulphate of lime. The combined weight of these salts is called the *Residue Soluble After Evaporation* and it has a most important bearing on waters used for irrigation

*Alkalimetry*.—An alkali is a substance which generally has a soapy taste and feeling, the power to attract and decompose organic matter and neutralize acids. It can be recognized by turning red litmus paper blue. It is an undesirable constituent of some of our waters and soils. It is known in its caustic forms as quicklime (oxide of calcium) and lye (caustic soda or caustic potash.) In waters it is seldom found in this form because of the abundance of carbonic acid gas, with which the caustic alkalies combine to form carbonates or so called "mild alkalies." Sodium Carbonate is a common and typical mild alkali,

*Sodium* and *Potassium* are classed as alkali metals. Most of their salts, like chloride of sodium, (common salt) are neutral; some, like carbonate of soda are alkaline; all ordinary salts of these metals are soluble in water. There is such a resemblance between the salts of these metals that for ordinary purposes a description of one will apply to the other. Sodium salts are much more common. Potash salts would have more value as fertilizers.

*Chloride of Sodium*, or common salt, is seldom absent from waters. It is harmless in small quantities and is readily distinguished by its taste

*Sodium Sulphate* (Glauber's Salt) is found in some waters. It has a bitter taste and acts as a purgative. Mineral waters often contain large quantities. The salt is not an alkali and is not poisonous but it is not desirable in drinking waters in more than small quantities.

*Sodium Silicate* is found in small quantities in some waters. As usually present it is perfectly harmless.

*Sodium Carbonate* (Sal Soda) is the substance which gives the distinctive reaction to alkali soils and waters. It has an unpleasant

soapy taste and in large quantities is undesirable in either drinking or irrigation waters. Its harmful action in soils can be prevented by the use of sulphate of lime (gypsum) which changes the carbonate of soda to carbonate of lime and sulphate of soda.

*Calcium* and *Magnesium* are classed as alkaline earths. As a class their salts are less soluble than salts of sodium and potassium and therefore much less harmful in irrigation waters. The calcium salts are generally more abundant than magnesium,

*Calcium Carbonate*, otherwise known as Calcite, Chalk, and in a less pure form the "Calichi" of our subsoils, is only slightly soluble in pure water. When the water contains carbonic acid gas, however, it can hold in solution comparatively large quantities. On evaporation this does not again become soluble and does the soil no harm. It is deposited on the sides of kettles and boilers, because the heat having driven the carbonic acid gas out of the water the carbonate of lime is no longer held in solution,

*Sulphate of Calcium* (Gypsum) is found as a constituent of many waters. It is only slightly soluble in pure water but when the water contains common salt and some other salts in solution it becomes more soluble,

After evaporation on the soil the sulphate of lime becomes insoluble and is beneficial.

*Sulphate of Magnesia* (Epsom Salts) is quite soluble in water. It has a bitter taste and acts as a purgative. In small quantities it is harmless, still it is not a particularly desirable constituent of drinking or irrigation waters,

*Iron* and *Manganese* are sometimes found dissolved in small quantities in waters. Iron is readily recognized by the dull red deposit. It is not often present in sufficient quantities to do any harm.

*Silica* or *Sand*.—Certain combinations of silica with the alkalis are soluble in water, and many waters contain a small amount of silica in solution. It is not objectionable in small quantities.

*Chlorine* in water is usually combined with sodium or chloride

of sodium or common salt. It is harmless by itself and in regions where the amount of chlorides in the soil is large need excite no suspicion.

Some chemists have used its presence as an indication of sewage contamination, and in regions where the amount of chlorine is uniformly small, a water which contained a large amount would be looked on with suspicion.

*Organic Matter*.—When a water is evaporated to dryness and the residue is heated there is sometimes a blackening of the deposit and an odor of glue or burned hair. This is a proof that the water contains organic impurities, and such water, while not injurious for irrigation purposes, is not safe to drink.

*Free Ammonia*.—Organic matter, vegetable and animal, contains nitrogen. In the process of decomposition the organized nitrogen breaks up into ammonia and nitrates. On being distilled the ammonia comes over first and can be very accurately measured.

*Albuminoid Ammonia*.—After the free ammonia has been distilled from the water an alkaline permanganate is mixed with the residue and the distillation is carried further. This decomposes the organized nitrogen into ammonia, which is distilled and measured as albuminoid ammonia. Thus the amount of free and albuminoid ammonia is taken as a measure of organic impurity. A water which contains considerable free ammonia but no albuminoid ammonia may be considered as organically pure. If, however, it contains more than .015 parts of albuminoid ammonia per 100,000 it should be regarded with suspicion for drinking purposes.

A water might be pure at its source, while by the accumulation of vegetable matter in the pipes or impurities in reservoirs through which it passes it may become contaminated,

*Hardness*.—Waters are termed hard when they contain lime or magnesium salts in solution, as these salts "curdle the soap" by forming insoluble compounds with the soap, instead of making a lather, as would be done with pure or soft water. If 100,000 parts of water contains one part carbonate of lime in solution it requires a certain

definite amount of soap to precipitate the lime before a lather will be formed. A solution of soap is made of such a strength that one cubic centimeter will just form a lather with water containing one part of carbonate of lime per 100,000 parts of water. *Total hardness* is measured by the number of cubic centimeters of this soap solution necessary to form a lather with a definite quantity of water minus the amount which is required to form a lather with the same quantity of pure water. *Permanent Hardness* is measured by the number of cubic centimeters of the soap solution necessary to form a lather with the same quantity of water after it has been boiled. This will be a less number as the carbonate of lime has been precipitated and the hardness remaining is mainly due to sulphate of lime or magnesium. *Temporary Hardness* is the difference between total and permanent hardness and is the measure of the carbonates of lime or magnesium. Such data is of value in comparing waters and in estimating the value of a water for boiler use.

The figures in a water analysis must be studied with regard to the purpose for which the water is to be used. As various as are the uses they may, for convenience, be divided into four classes:

- Potable waters,
- Irrigation waters,
- Boiler waters,
- Mineral waters.

*Potable Waters.*—Under the head of potable waters would be included all waters used for domestic purposes. It is of course necessary that they contain no poisonous or injurious salts or metals. Water sometimes dissolves lead from lead pipes, copper from copper tanks or arsenic from arsenical ores. It is not regarded as desirable that a water contain a large amount of total solids but it is difficult to define the limit. If the quantity of sulphates of magnesium and soda be not too large and there is but little free alkali and no organic impurity, a water which has eighty or even one hundred parts of total solids to the 100,000 may be used for drinking purposes without apparent ill effect. It is needless to say that a water should be as organically pure as possible.

The amount of free ammonia should not be excessive, but it is to the albuminoid ammonia that we should look with greatest care.

A water containing more than .015 parts of albuminoid ammonia should be looked on with suspicion ; less than that is generally, but not always, safe.

*Irrigation Waters.*—Except the filling up of ditches and canals there is no objection to a water being used for irrigation purposes which contains matter in suspension. This suspended matter may contain valuable fertilizing material, especially for sandy lands where clay helps so much to improve the mechanical condition.

The suspended matter in the water of the Colorado river was analyzed at this Station. The sample taken May 22nd, 1891, river 23 feet high at the Yuma S. P. R. R. bridge, gave the following analysis :

	PARTS PER 100,000
Suspended Matter.....	230
Total Solids—Matter in Solution.....	30
	—
Total Suspended and Soluble Matter	260

Of the 30 parts of total solids, 21 parts were again soluble after evaporation.

The suspended matter had the following composition, expressed in terms of percentage :

Water and Organic Matter .....	5.170
Sand .....	62.150
Lime .....	7.14
Magnesia .....	0.977
Ferric Oxide.....	2.610
Clay .....	20.270
Soda .....	0.372
Potash .....	0.836
Carbonic Acid .....	2.820
Phosphoric Acid.....	0.085
Total Nitrogen.....	0.054
Chlorine.....	0.014

If thirty inches of this water were evaporated on an acre of soil, there would be deposited from the matter in suspension 15,622 pounds ; from the matter in solution 2037 pounds, a total of 17,659 pounds of solid matter added to the soil. Of this amount there would be :

Clay.....	3167.0 pounds.
Lime.....	1115.0 "
Phosphoric Acid.....	13.3 "
Nitrogen .....	8.4 "
Potash .....	130.6 "

This amount of clay added to a sandy soil would materially help

its condition, while the amount of Phosphoric Acid, Nitrogen and Potash would be clear gain. This is all beneficial to the soil, but there would be added at the same time a considerable amount of solids soluble after evaporation. Most of this consists of Chloride of Sodium (common salt), Sulphate of Soda (Glauber's salt), and Sulphate of Magnesium. This, while not particularly beneficial to the soil, would have no ill-effect for some years. As the land is planted and becomes of more value, methods of neutralizing and leaching could be used which would be simple, cheap and effective. Deposits of gypsum are reported in various portions of the territory, and will no doubt be available by the time they are needed. A water having a large amount of total solids, all of which was insoluble after evaporation, would not be detrimental to the soil.

*Boiler Waters.*—Waters to be used in boilers should be as free as possible from total solids. Here again, the kind of material plays an important part.

Boilers are damaged by water in two ways—by corrosion and by the formation of a deposit or scale. In the former case corrosion may be the result of one or all of three different conditions, 1st.—Action of water on iron, especially when heated. 2nd.—The action on the iron of the gases held in solution in the water. 3d.—The action of gases formed by the decomposition of salts at the high temperature existing in the boiler. An ordinary chemical analysis would not indicate the extent of this corrosion except in the latter case, when magnesium chloride does most harm. Special work would have to be done with individual waters to indicate a remedy.

To determine whether the total solids of a water will deposit a scale or a sludge, examine total and permanent hardness. While the total hardness may be large, if the permanent hardness is small, it indicates that the hardness is mainly due to the carbonates of lime and magnesium. In this case simple boiling or the action of quicklime causes the carbonates to precipitate. Even if it be allowed to deposit in the boiler it will be in the form of a sludge which can be blown off. If the permanent hardness remains high, it indicates the presence of sulphate of lime. This causes a hard scale which is injurious to the boiler and difficult to remove.

A large amount of magnesium and chlorine is a bad feature in a water unless the amount of carbonates is large.

*Mineral Waters.*—Not much need be said here concerning mineral waters. It is often difficult to draw the line between ordinary drinking waters and mineral waters. Mineral waters may be said to be waters of various temperatures holding in solution certain quantities of salts supposed to have a medicinal effect on the human system. A chemical analysis does not always explain the hygienic effect claimed for the water.

The Station cannot undertake the analysis of mineral waters except in cases where the interest would be more than local.

### SOME WELL WATERS.

Water from University well, situated on mesa one mile north-east of Tucson; soil a sandy loam, varying from three feet to nothing, where subsoil is exposed. Subsoil (calchi) consists of carbonate of lime, with about equal quantity of sand, with a small amount of iron and clay and traces of phosphoric acid, in the form of a hard cement.

The subsoil is from four to seven feet in thickness, and below this is found sand, formed from decomposed granite. At a depth of eighty-four feet from the surface water was found. Well is about 95 feet deep; water clear, odorless and tasteless, with temperature of 76° F.

An analysis showed the presence of the following constituents :

	PARTS PER 100,000
Total Solids .....	25 00
Soluble Solids .....	14.00
Insoluble Solids .....	11.00
Sodium Chloride.....	1 53
Potassium Chloride.....	0 50
Sodium Silicate.....	4 00
Sodium Sulphate .....	3 20
Calcium Sulphate.....	2.38
Calcium Carbonate .....	7 32
Magnesium Carbonate .....	3 50
Free Ammonia.....	0.002
Albuminoid Ammonia .....	0.005
Water of Combination .....	1 57
Total Hardness .....	10 6
Permanent Hardness.....	3 0
Temporary Hardness.....	7 6

This analysis shows a water free from undesirable substances, excellent for domestic purposes, irrigation or boiler use. The comparatively small amount of total solids, freedom from organic impurity and small amount of permanent hardness makes it a safe water in every respect. The supply is abundant and can be reached anywhere on the mesa at depths varying with the elevation.

*Well water* from ranch of Wm. Hartt, 18 miles south-east of Tucson. Soil a rich loam with abundant supply of water at 40 feet. Water is clear, odorless and tasteless. Mr. Hartt has a pump with a capacity of 2,500 gallons per minute, and can irrigate a section of land. The water is excellent for irrigation purposes, the large amount of sulphates being an advantage. The analysis gave :

## PARTS PER 100,000

Total Solids .....	33.00
Soluble Solids .....	20.00
Total Hardness .....	21.50

Well water from the ranch of A. V. Grossetta, 3 miles south-west of Tucson ; soil very sandy loam, with abundance of water at 35 feet. Water is clear, odorless and tasteless. It is a good water for irrigation but somewhat hard for domestic use, though it can be much improved by being boiled. The analysis gave :

## PARTS PER 100,000

Total Solids .....	48.0
Soluble Solids .....	32.0
Total Hardness .....	22.0
Permanent Hardness .....	6.5
Chloride of Sodium .....	4.2
Sulphate of Sodium .....	15.6
Sulphate of Lime .....	7.2
Carbonate of Lime and Magnesia .....	14.0

### SOME RIVER WATERS.

It is intended to make an extended examination of the waters of the rivers of Arizona. A few analyses are given here to show something of the character of the waters. The samples taken from the Rillito and Santa Cruz differ widely, although the rivers at the point of sampling are not more than six miles apart.

The samples from the Gila and Colorado were sent by Mr. H. W. Blaisdell. Those from the Gila were taken at his ranch, nine miles above Yuma, while those from the Colorado were taken at the S. P. R. R. bridge at Yuma, below the junction of the Gila. It is interesting to notice, that while the water of the Gila is at times somewhat heavily charged with salts of sodium and lime, the waters of the Colorado have but a moderate amount. The examination of the water of the Colorado has not been sufficiently extended to make positive statements, but the samples which have been examined show a comparatively low amount of total solids in solution, and no appreciable amount of substances injurious to vegetation. On the other hand, the sediment carries large quantities of the elements of fertility, which would be of special value on sandy lands.

## RIVER WATERS.

NAME OF RIVER.	DATE SAMPLED.	Total Solids.	Solids Soluble after Evapor'n	Solids Insoluble after Evapor'n	Total Hardness.	Permanent Hardness.	Chloride of Sodium.	Sulphate of Lime.	Carbonates of Lime & Magnesia.
Rillito .....	March 5, '91..	10..	5..	5..	4 ..	2 ..	2 ..	2 ..	4.2
Santa Cruz...	March 5, '91..	73..	62..	11..	26 ..	4.5..	7.1..	4.8..	20.0
Gila .....	April 7, '90...	59..	38..	21..	17.5...	4.0..	30.0..	3.2..	15.1
Gila .....	May 3, '90 ...	95..	70..	25...	30.0...	8.0..	65.5..	7.3..	18.3
Gila .....	May 20, '90...	102..	97..	15...	33.6...	9.0..	84.2..	7.8..	19.2
Gila .....	Aug. 9, '90...	74..	66..	18...	15.7...	10.0..	53.4..	5.6..	6.5
Gila .....	Nov. 18, '90..	44..	43..	12...	16.7...	6.0..	27.0..	4.5..	8.3
Gila .....	Dec. 2, '90...	75..	52..	23...	23.4...	7.0..	49.6..	8.6..	13.0
Gila .....	Dec. 16, '90..	39..	21..	18...	16.7...	4.0..	30.7..	2.8..	9.7
Gila .....	Jan'y 2, '90...	41..	31..	10...	13.2...	5.0..	23.7..	3.3..	6.9
Colorado.....	May 2, '90 ...	38..	24..	9...	17.0...	4.3..	14.4..	8.6..	3.5
Colorado.....	May 15, '91...	26..	19..	7...	16.0...	5.0..	7.0..	9.0..	3.1
Colorado.....	May 22, '91...	30..	21..	9...	14.0...	4.5..	8.2..	8.8..	3.3

C. B. COLLINGWOOD.