ENGINEERING REPORT

MASTER PLAN
WATER SYSTEM
FOR
INDIAN HILLS WATER DISTRICT
Jefferson County, Colorado

WRIGHT-McLAUGHLIN ENGINEERS
ENGINEERING CONSULTANTS
DENVER, COLORADO

MARCH, 1972

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March 31, 1972

Board of Directors
Indian Hills Water District
Indian Hills, Colorado 80454

RE: Letter of Transmittal - Summary

Gentlemen:

Forwarded attached is our Engineering Report, Master Plan of Water System, prepared as directed by the Board.

The more significant problems presently facing the District are:

A. A very limited water supply which can support far less than potential area development.

B. Marginal chemical water quality due to high nutrient-dissolved solids contamination.

C. The physical water system is of general poor quality, and cannot furnish year-round water to most areas.

The groundwater portion of this Report is based on a previous study by Dr. David T. Snow. The hydrological findings of this study agree practically with Dr. Snow's work - resulting in an estimated critical year maximum yield of 70,000 gpd (gallons per day). Supply is limited by the topographic boundary of the Parmalee Gulch Basin. Any project involving importation of outside water will be relatively expensive and economically infeasible based on present District resources. Assuming no irrigation, the critical in-basin yield would support an estimated 270 full-time residential units. There are approximately

350 buildings in Parmalee Gulch now. If it is assumed that ultimately 1/2 of the residences would be full-time and 1/2 for weekend use only, then 420 units (210 full-time) would be possible. These numbers are based on minimum individual use and the system should be designed to provide additional water when available. A risk would be involved in permitting a total of 420 residential units in that the number of conversions to full-time residency could exceed 50%.

By contrast, neglecting water supply and sewage disposal constraints, existing plats and zoning could permit as high as 3400 residential units to be built in the area. However, because of lack of water and the resulting need for a community-type sewerage system, growth over the approximately 420 units would be "a new ball game."

Poor water quality is due to poor well construction and location. Chemical contamination from surface runoff and septic tank effluents has increased nitrate and other dissolved solids levels. Recommendations contained herein, and in the Snow Report, will resolve quality problems.

Much of the distribution system is of steel pipe lying on the top of the ground. Alpine Village has the only winterized system. Storage tanks are of thin steel construction, and in generally poor condition. The system does not provide adequate zoning for good pressure control.

Several alternatives were investigated during preparation of the Master Plan. A conventional municipal water system was determined too costly for consideration. Water importation would require at least 1/2 million dollars initially and, is, therefore, not presently possible. An optimum, economical, all-year system, suited especially for Indian Hills has been designed and proposed. Other more exotic alternatives could include individual recycling of sanitary flows, or a District sewerage system with recycling through a dual water system. These would probably prove impractical at present development levels, and are beyond the scope of this Report.

The following actions are proposed for adoption by the Board.

RECOMMENDATIONS

1. The Board should adopt the Master Plan and design future improvements to be in conformance with this Plan.

2. The Board should adopt and implement policies limiting growth in the Parmalee Gulch Basin to approximately 420 dwelling units (or equivalent). This action will probably require hearings with the County Commissioners, and the Planning Commission. Also required is a study by the District's Attorney to evaluate legal problems involved with limiting future service within the District.

3. The District should consent to any major new development only if acceptable systems for water importation and sewage disposal are furnished by the developers.

4. The Board should proceed with the recommended improvements program as described in the Report. This program includes water right acquisition and actions, new wells, a new storage tank, and a generally new winterized distribution system - estimated capital cost is $315,400.

5. Application should be made to the Farmers Home Administration (FHA) for a loan and grant in order to finance recommended program.

6. If FHA financing is not available, the Board should proceed with the minimum program discussed in this Report ($79,000) using private financing. Under this program, the District would obtain water rights and a water supply of good chemical water quality. Since subsequent construction should be in

accordance with the Master Plan, the resulting facilities under either the recommended program or the minimum program would be the same.

7. The Attorney for the District should provide a legal opinion regarding the water right ownership and needs of the District. A determination should be made as to acquisition of specific water rights for the District, and such option or purchase should proceed with diligence. A change in point of diversion suit should be initiated in the Water Court at Greeley.

We will be available to meet with the Board to discuss the Report on request.

Respectfully submitted,

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Attachment

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WATER SYSTEM
FOR
INDIAN HILLS WATER DISTRICT
JEFFERSON COUNTY, COLORADO

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SECTION 1

INTRODUCTION

GENERAL BACKGROUND

The Indian Hills Water District is located in Sections 6, 7, 8, 16, and 17, Township 5 South, Range 70 West, approximately twenty miles west of Denver. It is located in the Parmalee Gulch valley and ranges in elevation from 7,600 feet to 6,760 feet. The maximum elevation of the surrounding mountains is 8,630 feet. The approximate original District boundaries are shown on Drawing 1.

The Indian Hills Water District was formed in 1952, although the water system was started in the 1920's. Development proceeded principally as a summer-use area and the District's facilities developed accordingly. In 1962, a year-round system was installed by ESCO, in the Alpine Village area, with costs shared by the Jefferson County School District, the Indian Hills Water District, and ESCO. Gradually, the valley homes have been transferred to year-round residences. In addition to the homes on the winterized Alpine Village system, there are approximately twenty-five homes which haul water in the winter, and there are others with individual wells and storage reservoirs, which are filled in the fall for winter use.

During the Spring of each year, the summer system is activated and meters are installed. During the summer, there are about 170 total customers. The summer system is de-activated about October.

The District has no central sewage facilities to serve its customers. In many areas, decomposed bedrock (usually granite) is within one or two feet of the surface, causing some difficulty with leach fields. Alluvial material is limited in the basin. There is some in the middle and lower reaches of Parmalee Gulch to depths of 6 or 7 feet or greater, but most is in the upper reaches of the basin on drainages that are intercepted by Parmalee Gulch.

AREA DEVELOPMENT

The existing valley development is primarily rural-domestic. There are an estimated 350 dwelling units in the valley, with about 220 dwelling units located in the District. However, the District has only 170 total winter and summer customers. The current assessed valuation of the District is $966,050.

The District covers approximately 1,020 acres, which is a density of about 1 dwelling unit per 4.5 acres; however, because the development is centered in two general areas, the density is about 1 unit per 2 acres in some of the developed areas.

FUTURE DEVELOPMENT

If the valley could develop to full lot occupancy, the area would be a mountain suburbia. Most of the District is zoned for 2-family dwellings if the lot size is sufficiently large; however, most of the lots in the District can support only 1 dwelling unit. There are an estimated 3,234 lots in the valley, of which perhaps 1,800 lots are in the District. It is estimated at full development under existing zoning regulations, there could be as many as 3,420 dwelling units, plus some limited commercial, non-dwelling units. Of this number, approximately 2,000 could be located in the District. The maximum valley population could range from 10,000 to 12,000 people on existing lots, if growth was not restricted by law or by resource limitations.

Future development is uncertain. No comprehensive development plan has yet been made for the Parmalee Gulch Basin. Most current development pressures are centered in two areas, one on each end of the District. In each area, there are a number of homes and a few small shops and stores. It can be concluded that water availability is the critical item which will fix the maximum development level in the Indian Hills area.

PURPOSE OF REPORT

The Indian Hills Water District system is a result of several individual additive construction projects, apparently accomplished without benefit of a coordinating overall system plan. In addition, the Board has recently become aware of basic water source problems, both as to quality and quantity.

The purpose of this Report is to present a comprehensive optimum Master Plan to guide the District's capital and operational improvement programs. It is intended that this Master Plan should resolve the basic water rights - treatment - supply-storage-distribution systems design. However, detailed problems such as precise pipeline and tank locations, etc. are to be resolved during final design engineering efforts. Water supply portions of this Report are based on previous groundwater investigations done for the Board by Dr. David Snow.

SECTION II

EXISTING FACILITIES

GENERAL

The existing system is divided into two geographical areas, Upper Parmalee Gulch and Lower Parmalee Gulch; the two being connected by a single two-inch steel line. Both areas are supplied by wells and have separate storage facilities. Drawing 1 shows the location of the existing water system components.

WATER SUPPLY

The District is supplied by water from nine wells in the Parmalee Gulch basin. The locations and numbers are shown on Drawing 1. Only two wells are used the year around, Well Nos. 1 and 5. Well No. 1 supplies the lower portion of the District with winter water, which is pumped into a tank truck for distribution. Well No. 5 was developed by ESCO and was turned over to the District with the distribution system for Alpine Village. All wells are considered shallow and tap tributary water sources.

Well No. 1, a dug well with a submersible pump, is deficient as to State Health Department requirements because:

1. The top 10' of the well casing are not sealed.
2. It is located in the bottom of the Parmalee Gulch and is not sufficiently distant from the main water course. In addition, it is susceptible to flood damage and has sustained damage frequently.
3. Chlorination is made directly to the line without sufficient contact time.

Chlorination is done by a Wallace and Tiernan bottle-mounted chlorinator using a booster pump. If this installation were retained, some revision

revision would have to be made to the chlorination piping. The heater is on the floor and is under the chlorinator piping, and there is no air release on the discharge line. Well No. 1 taps tributary water.

Well No. 5 is a dug well with a vertical turbine pump. At this time, disinfection is done by hyporchlorination, as the pump for the W-T bottle-mounted chlorinator is inoperative. Normally, chlorination is by a chlorine solution injected into the discharge line. This well supplies the Alpine Village winterized system, and provisions have been made to supply a portion of the summer system. It is deficient by State Health Department standards because:

1. The upper 10' of the encasement are not sealed.
2. There is insufficient contact time for chlorination.
3. It, too, is probably located an insufficient distance from the thalweg of Parmalee Gulch, although it is not as susceptible to flood damage as is Well No. 1.

At Well No. 5, most of the equipment in the installation is generally acceptable, if items such as the chlorinator are working properly; however, the manner in which the equipment is used may need revision. As with Well No. 1, there is no air release valve on the discharge line.

Of the remaining wells, some are dug, some are drilled, and all are used primarily for the summer system. Well Nos. 2, 7, 8 and 9 have identical surface installations using hyporchlorination and submersible pumps. They have the same basic deficiencies as Well Nos. 1 and 5 and are susceptible to flood damage.

Well Nos. 3, 4 and 6 do not have any buildings or chlorination facilities. Well No. 6 is connected with the Alpine Village system. Well Nos. 3 and 4 are not connected to any system. All of these wells are susceptible to contamination from surface runoff.

To date, the maximum average daily water production has been about 11,000 gallons per day (GPD) when averaged over a quarter of the year. The maximum daily output in the summer is probably 20,000 to 25,000 GPD. This is near the estimated upper limit of the present system's water production capability.

WATER QUALITY

In 1971, Orville Stoddard of the Colorado Department of Health completed a study of the water supply, made recommendations relative to improvements, and commented on pollution problems and test data. Tests by the Colorado Department of Health and others, to determine water quality, have indicated high levels of nitrate (NO_3) concentrations, and some tests have exceeded Colorado Department of Health standards. The presence of nitrates is an indicator of other salts being present in water. For reference, the results of the tests are listed in Table II-A.

TABLE II-A

NITRATE CONTENT IN INDIAN HILLS WELL WATER

Date	Well Number 1	2	3	4	5	6	7	8	9
7/10/67	8								
11/18/68	43				82				
12/ /68	43								
5/ /69	13	21	11	44	37	50	27	24	
5/20/69	45								
10/21/69	29								
11/ 5/69	31								
1/29/70	16				27				
3/ /70					38	44			
3/26/70	6				6				

TABLE 11-A (Continued)

Date	Well No. 1	2	3	4	5	6	7	8	9
4/ /70	5.5				6				
6/ 4/70	22				28				
7/23/70	25	19	3	19	26	33	30	37	
8/21/70	12	2	0	2	26	30	32	28	
9/24/70	5	15	0	0	28	30	34	39	
10/15/70	15	0	0	0	29	27			
11/19/70	15	0	3	3	30	28			
12/22/70	15	3	18	1	28	27			
1/21/71	12	0	1	1	31	28			
2/18/71	22	0	0	5	28	28			
3/26/71	11	0	0	20.5	27.8	29.5			
4/29/71	12	6	0	5.5	26.5	28.5	30.0	26.0	4.5
6/24/71	12.5	0	0	23	23	23.5	27	32.5	
7/24/71	10	0	1.3	24	17.5	7.5	27	35	
8/26/71	0	0	0	21.5	23.5	28.5	28.5	32.5	
9/23/71	4.8	0	0	4.0	23.5	29	30.0	33.5	

It can be noted that the nitrate concentrations have been steadily dropping since 1969, for which there are two probable reasons. The obvious reason is that the pollution level is dropping and could be the result of any combination of the following:

Improved sewage treatment

Less use of sewage treatment systems

Better watershed management practices, resulting in less pollution from surface sources

It is improbable that any of the above items could have significant enough impact to cause the reduced nitrate levels noted in Table II-A.

The second possible reason for dropping nitrate concentrations is that the pollution level has remained relatively constant or has even increased, which could be the result of the following:

Revised testing procedures
Change in precipitation amounts or distribution resulting in changed percolation characteristics
More nitrates, amonia, or organic nitrogen which indicates a worsening of pollution

A complete chemical analysis will indicate which of these or other phenomenon are affecting the nitrate concentrations. It is most likely that the pollution is increasing due to increased land pressures and that nitrate concentrations are an inadequate indicator of pollution.

The existence of salts such as nitrates, indicates reuse of water resources. Without special treatment, these salts and other pollutants can be expected to accumulate to greater concentrations in the ground waters and in the aquifer, causing the supply to be inappropriate for domestic use.

STORAGE

Although poorly distributed for a conventional system, the District has a fairly large clear-water storage capacity. There are presently four storage reservoirs, in three separate locations, actively operated by the District. Serving Alpine Village are two reservoirs, totalling 35,000 gallons of storage which are filled from Well No. 5. The water levels are controlled by electrical probes. These reservoirs are thin-walled, on grade, steel, and have an estimated useful life of perhaps 10 years.

In the lower portion of the District there are two reservoirs, one on each side of the valley. The reservoir on the north side has a 15,000 gallon capacity and is filled by Well No. 1. The reservoir on the south side has a 10,000 gallon capacity and is filled from Well No. 2. Neither reservoir is used during the winter.

The 15,000 gallon reservoir is a steel, on-grade tank with an estimated life of 10 years. The 10,000 gallon reservoir is a steel, on-grade tank, is in poor condition and is probably past its useful life. The reservoirs operated by the District provide gravity service to all but a small portion of the District.

In addition to the District-operated storage reservoirs, there are numberous private storage reservoirs, some as large as 15,000 gallons. These reservoirs, while serving a useful purpose at present, would be of limited value in a conventional system.

DISTRIBUTION SYSTEM

A summer water distribution system was started in the 1920's and proceeded in a haphazard manner to present. The system consists primarily of two-inch steel pipe installed on or near the surface, and generally on back lot lines rather than in roads. The Alpine Village system is fairly well documented; however, general District records and maps do not indicate most line sizes, and locations shown on Drawing 1 for water lines are only approximate. The lower portion of the District is entirely a summer-use system. Interspersed between users are a number of homes with private wells. In addition, there are some homes which are served by the truck haul system used in the winter.

The upper portion of the District has a winterized, domestic-type water system serving part of the area and a summer system similar to the lower portion serving the remainder. The summer system is connected to the winterized system at Well No. 5. Connecting the upper and lower portion is a single two-inch steel line with a few scattered users connected to it.

The winterized system in Alpine Village consists of mostly four-inch cast-iron mains with some six-inch cast-iron and some two and one-half inch galvanized steel pipe. The specified depth of bury was five feet.

The Alpine Village pipe system is in good shape with little maintenance required. The condition of the summer system is varied, with some of the system past its useful life and with some portions in sufficiently good condition for perhaps 5-10 years of future service.

There are no defined pressure zones; although, because of the control system for reservoir filling, there are two functioning pressure zones. Practically speaking, the lower portion of the District "rides" on the lower reservoirs and the upper portion "rides" on the two reservoirs installed by ESCO. These two reservoirs are at different elevations which cause hydraulic problems for using the total capacity of both reservoirs. If two reservoirs serve areas at the same elevation, the water in the lower reservoir cannot be used unless there are large enough line losses or the higher tank is emptied.

EXTENSION OF SERVICE

In general, there has been no policy governing tap-on requirements. In other words, the choice to tap on to the District's system has been left to the individual and has resulted in numerous exclusions and/or individual wells.

The past approach to water system planning and construction has resulted in a generally inadequate system.

SECTION III

WATER RESOURCES

GENERAL

The Indian Hills Water District, lying between Turkey Creek and Bear Creek is a relatively dry area similar to most of the foothill country lying west of the Denver Metropolitan region. The configuration and high elevation of the District provide only limited drainage catchment areas.

Parmalee Gulch drains through the center of the District, Bear Creek lies to the north, and Turkey Creek flows along the southern edge. The small gulches in the District carry runoff during the wetter periods, however, these small gulches tend to dry up during late summer months.

Wells drilled into the bedrock have yielded water for the District and for scattered residential homes, but even here, there has been somewhat of a history of water supply problems from time to time as well yields proved inadequate with increased use.

WATER RIGHT CONSTRAINTS

From a general water resources point of view in Colorado, the principal limitations on water supply are:

a. Physical Availability. This is the quantity of water usually expressed in cubic feet per second (cfs) that is present in the stream at various times of the year at the several locations where the water may be diverted from the natural stream. Bear Creek is largely fed by melting snows in the mountains to the west. Stream flow varies widely from month to month, with the highest flows occurring during the snowmelt runoff season in May or June.

b. Legal Availability. This has to do with the quantities of water which may be diverted from the natural stream under the water rights owned by the diverter. At times, when there is not sufficient water physically in the stream to satisfy all diverters, senior water rights take precedence over junior water rights. A senior water right is one that has an earlier priority than a junior right.

There are two categories of water rights as regards to how soon after diverting the water that it is used. Direct-flow rights are for water diverted from the stream into a ditch and then carried to a farm, hay meadow, or to a water plant and put to use more or less promptly. Storage rights are for waters which are diverted from the flow of the stream and placed into a reservoir to be released for use at some later time, within the same year, or in a subsequent year. Diversion for a storage right may be either for a reservoir off the channel of the stream from which it was diverted, or it may be for an on-channel reservoir.

The diversion of water by the District from public streams is subject to the laws of the State of Colorado. At times, when there is not sufficient stream flow to satisfy the demands of all water users, the State regulates and controls diversions. The State's authority is exercised by the State Engineer and subordinate water officials. For purposes of water administration, the State of Colorado is divided into a number of Water Divisions. Regulation within a division is done by the Division Engineer. The stream basin in which the District is situated is tributary to the South Platte River, whose basin makes up Water Division No. 1. Turkey Creek and Bear Creek are tributary to the South Platte River.

The State regulates diversions on the basis of priorities which are decreed by the Courts in the order in which the water was first appropriated and put to beneficial use. A water right with an early appropriation date takes precedence over rights with later dates. All water rights in one general adjudication are usually senior to those decreed in a later adjudication, irrespective of appropriation dates. The variations from this rule relate to non-irrigation rights adjudicated after 1902, but this is a complicated subject for water law specialists. The Court Decrees establishing priority also specify the permitted magnitude of diversion in terms of a rate-of-flow, or by volume of water in the case of storage rights.

Much of the South Platte River is, part of the time, an over-appropriated river; that is, there are more water rights than there is water. A senior appropriator, one with an early date, whose right is not satisfied by the stream flow at his headgate, may call for water that is being diverted upstream by a junior right. The call upon the junior is made through the Division Engineer, who can order the junior to shut his headgate, or who can physically close the headgate himself. This administration of water rights is actively carried out on the South Platte River.

A municipal water system has the obligation of furnishing water to its customers as it is demanded, every day, year after year. To meet this obligation, the system must have the legal right to take water at the times, and in the amounts needed.

WATER RIGHTS IN PARMALEE GULCH

Contact was made with Mr. Allen P. Mitchem, Attorney for the District, in regard to an inventory of water rights owned or controlled by the District. Information obtained indicated that the District owned no water rights of significance relative to the Bear Creek or Turkey Creek basins.

A review of the State Engineer's tabulation of all water rights in the South Platte River basin was made to identify those rights situated in Parmalee Gulch. This review indicated that 7 water rights are in existence in the subject basin. Table III-A below summarizes these rights. At this time, we have no information or record indicating whether the Indian Hills Water District owns or controls these water rights. However, from our inspection, we believe that the District probably controls PL No. 1, PL No. 2, and PL No. 3. In addition, Ten Brook Pipeline would be typical of old water rights owned or controlled by the District or one of its users. The District should proceed further in an attempt to identify the ownership of the Lynn PL, the Kirchhoff PL, and the Ten Brook PL, and the Attorney for the District should provide an opinion regarding the water right ownership and needs of the District.

TABLE III-A

WATER RIGHTS IN PARMALEE GULCH BASIN

Name of Structure	Name of Source	Amt. (cfs)	Section (T5S, R70W)	Appr.* Date	Tab. No.
Kirchhoff PL SP GP 5	Cox Spring No. 2	---	9	3/01/1880	568
Kirchhoff PL GP 5	Cox Spring No. 2	---	9	3/01/1880	804
Lynne PL	Cox Spring No. 2	0.05	7	9/14/1910	2025
Indian Hills PL 3	Cox Spring No. 2	0.10	7	6/01/1913	2092
Ten Brook Pipe line	Parmalee Creek	0.25	17 SWNWNE	5/15/1918	2190
Indian Hills PL No. 1	Well under-ground	0.10	16 SESWNW	6/01/1923	2432
Indian Hills PL No. 2	Well under-ground	0.10	17 NENE	6/01/1926	2526

*All of these rights were adjudicated on 9/24/1935, the previous adjudication being on 2/04/1884.

In Water District No. 9, the 1935 adjudication was the first adjudication for non-irrigation water rights, and for that reason, the above non-irrigation water rights are equal to those water rights adjudicated in the first adjudication for irrigation purposes. With regard to the adjudication, this means that the appropriation dates can be compared directly with those appropriation dates from the first adjudication.

It will be noted that the earliest water right in Parmalee Gulch is March 1, 1880. This water right is very late for the Bear Creek drainage basin, and is subject to being shut down regularly during the summer months. Based on the above information, the water rights shown in Table III-A are good to have and should be clearly owned by the District if at all possible. However, relative to Bear Creek and Turkey Creek rights, they are not suitable to provide Indian Hills with a dependable legal supply of water for the future. With that in mind, it will be necessary to make senior water rights acquisitions in the Turkey Creek or Bear Creek drainage basins in order to provide the kind of dependability necessary for a municipal water supply.

Water rights which would be of interest to the District are situated in Warrior Ditch, Pioneer Union, and the Hodgson Ditch. In addition, we believe the Ward Ditch might provide some benefits, even though it primarily has water which is quite junior.

A determination should be made as to acquisition of specific water rights for the District, and such option or purchase should proceed with diligence. A change in point of diversion suit should be initiated in the Water Court at Greeley. Optioning of water should anticipate as much as 1/3 or 1/2 of the water rights being lost in the transfer.

PHYSICAL WATER YIELD OF PARMALEE GULCH

A hydrological study of Parmalee Gulch water yield has been made based upon the investigation of adjacent basins as to monthly and annual water yield for average and dry years. Basins which have been reviewed include Bear Creek, Turkey Creek, and Coal Creek. In addition, water yields of other basins have been considered.

Parmalee Gulch has a total tributary basin of 5.75 square miles. It has been estimated that the dry year water yield is 40 acre feet per square mile and that the total yield of Parmalee Gulch is approximately 250 acre feet in a dry year. Normal runoff is derived from precipitation which averages 18" per year. During the five month May - September period, 50% of the precipitation occurs. The other 9" occur from October through April. The estimated normal year yield from the Parmalee Gulch basin represents approximately 1" of runoff.

At any given time, there is a substantial amount of water in the basin as soil moisture, groundwater, and surface water. This water in "transient" storage has been considered tributary to Turkey Creek for the purposes of this analysis.

Water use in Parmalee Gulch Basin by the Indian Hills Water District is, to some extent, based on re-cycled water. That is, water is pumped from widely dispersed wells, distributed to water customers, and partially re-cycled to the groundwater table via sewage leaching fields. For this reason, the total water use by Indian Hills could probably exceed that portion of the basin yield which one would normally consider available for capture and use. Based upon efficient and widely dispersed wells, that water available for capture is estimated to be approximately 1/3 of the dry year basin yield, or about 80 acre feet. This annual volume of water averages out to 70,000 gallons per day. It is our opinion that this estimated average physical availability of 70,000 gallons per day should be considered as the maximum capturable water yield available to Indian Hills based upon present information and practical water diversion capabilities of the District. Re-cycling using sewage leaching fields would tend to increase this to some degree, but at this time, the magnitude is uncertain. Additional dependable water yield to the District should not be planned for from Parmalee Gulch without demonstration of its availability on a dependable basis. This would include dependability during a series of years such as 1954, 1955, and 1956 which were drought years.

For reference purposes, the 250 acre feet dry year yield of the Parmalee Gulch basin is distributed as follows on a monthly basis. That available for pumping from wells would be partially independent from the distribution below because of the storage aspect of the groundwater.

TABLE III-B

DRY YEAR YIELD OF PARMALEE GULCH

Month	Yield/Acre Feet
Nov	5
Dec	5
Jan	5
Feb	5
March	19
April	49
May	80
June	40
July	19
Aug	10
Sept	7
Oct	6
	250

SNOW REPORT

For reference purposes, the Dr. David Snow Report is included in the Appendix at the end of this Report. There are 5 new wells recommended in the Snow Report, located in the upper reaches of valleys which connect to Parmalee Gulch. The total estimated capacity of these 5 wells is 44,000 gallons per day, about 1/3 less than the estimated basin yield.

The primary reasons for the location of these wells in the higher reaches of valleys are to reduce contamination from septic systems and to locate the wells near favorable geologic fault zones. The Snow Report recommends the abandonment of the existing wells or the use of them as a reserve capacity, the recommendation being based upon their unfavorable location as to geologic formations and/or contamination.

SECTION IV

MASTER PLAN

GENERAL COURSES

From preliminary analyses, two alternate general planning courses became apparent:

A. Rely on local water supplies reasonably known and limit growth to the level that these supplies would support.

B. Assume normal development practices (plan for ultimate zones density) and rely on imported water.

Indian Hills lies in a critical water area of Colorado. All neighboring water supplies have been legally appropriated and most have been put to a high-type beneficial use. Any water importation project will involve extensive effort and be relatively costly. A minimum program which would bring in a new surface source would probably result in a capital investment of over one-half million dollars. To make such a program economically feasible would require the prior commitment of extensive additional growth within the District. No such commitment offers have even approached the Board. Further, planning goals have not been established and it is questionable if the District residents really want substantially higher densities.

Because Course B is not, for economic reasons, a viable course of action at this time, and because investigations indicate that the in-basin water supplies can be physically adequate for existing development, Course A has been chosen as a basis for the Master Plan.

There is some possibility of developing additional water locally through the drilling of deep wells. It is our opinion that the probability of this is not great. Fault zone water discussed by Dr. Snow would apparently be mostly locally recharged and, therefore, might not substantially increase long-term basin yields. Deep, non-tributary groundwater, if existent, could be in such low quantities or of such poor chemical quality as to make usage impractical. A proper District regulation would be to require new developers to provide imported tributary water or demonstrate the availability and feasibility of using deep, non-tributary wells.

Another alternative course of action, which should be discussed, would be that of eventual abandonment of the central system with a reversion to individual well supplies. In this event, certain areas, such as Alpine Village, might elect to remain on a single-source system. From a convenience (and probably a total cost) standpoint, this reversion would not result in a general improvement to the living quality in Indian Hills. For water resource and economic reasons, it is doubtful if a community sewer system could be installed for the Indian Hills area. Individual well supplies, coupled within the existing individual sewage disposal systems, would result in health hazards for many of the existing residents. Also, it is not likely that all existing homes could actually drill producing on-site wells. This general course would be inconsistent within the basic purpose of the Water District and has not been considered in detail herein.

GENERAL PLAN ALTERNATES

After conceptual effort, two system alternates were preliminarily designed, optimized and cost estimated. As to a recommended program for near-future Board implementation, three alternate programs were developed. These alternates can be summarily described following. The alternates mainly relate to the distribution system; the water source and supply facilities would be similar in either case.

1. Construct a conventional-type potable water system. This distribution system would consist of mostly 4-inch, 6-inch, and 8-inch water mains, designed using conventional municipal techniques. Lines would be all buried below frost depth for year-round use. Customers would receive pressurized water from the District on a continuous basis. The system would be designed to provide normal fire protection flows.

2. Construct a unique-type water distribution system, designed specifically for Indian Hills, to attain minimum costs.

   This system should supply all customers with safe, potable water on an all-year basis. Fire protection flows would be incidental only. The primary design differences involve the use of smaller piping, and of shallow bury insulated piping in rock areas. Some customers would probably have to maintain cisterns and in-house booster pumps for winter-time use. This type design is necessary to reduce construction costs in rock areas with minimal natural soil cover.

3. The third program studied is essentially the same as Alternate 2 above except with respect to timing.

   A minimum initial capital program would be adopted. Initial investment would include water rights and only the water supply improvements immediately necessary to produce adequate, safe water. Under this plan, the distribution system would be gradually replaced with permanent all-weather type construction. Replacements would probably occur at varying times for particular area groups -- as the demand for winter service occurred. Detailed system component design would conform to the Master Plan designed as devised for the Alternate 2 program. Replacement would probably require substantial individual tap fees at the time of construction.

Plan 1, the conventional-type system was preliminarily designed. The estimated capital cost, based on 1972 dollars, is $620,000. That is, in our opinion, a basically infeasible plan in consideration of the number of customers which could be served and their reasonable ability to pay for water service. If few additional customers can be added (because of the limited water supply), growth cannot occur which would result in a future favorable determination of feasibility.

The Master Plan proposed herein is essentially Alternate 2. Minimal initial improvements have been segregated so that the longer-term pay-as-you-go type program (Alternate 3) can be studied by the Board.

DESIGN CRITERIA

For Indian Hills the design criteria are governed by the physical limitation of water supply in Parmalee Gulch. As discussed in the previous section, the estimated firm yield of the entire Parmalee Gulch basin for the District is about 70,000 gallons per day (GPD), and this supply must be shared with other users in the basin who are not included in the District and who presently operate private wells.

Water Quantity. At present, the daily per capita water consumption is probably about forty gallons (gpc/d). This value is for domestic purposes only and is fairly standard in areas where water is trucked or stored in cisterns for winter use. Some users possibly consume less than that value. However, it is not reasonable to expect that these low values will continue into the future, particularly for full-time residents. For design and planning purposes, values approximately equal to those encountered in areas which presently have winterized systems should be used. Individual water use could increase as the convenience of water piped to houses becomes "taken for granted" and as the average character of customers gradually changes from part-time recreational to full-time residential.

Table IV-A shows the values normally used for water system design in areas of a similar development where water source is not limiting, as well as the recommended values for Indian Hills. The lower recommended values are possible because of the lack of irrigation in the District and because the present shortage of water supply will have some influence on individual water use policies. Unless water is imported, lawn irrigation could not be allowed during critical years.

Since the predicted water yield can support only 300 full-time equivalent residential taps, and there are presently about 350 homes in the Parmalee Gulch basin, the District should develop policies aimed at discouraging growth. If it can be assumed that the mix of permanent and part-time (weekend) residents is approximately 50 - 50, the estimated dry year yield can support up to 420 dwelling units, being 210 full residences and 210 part-time residences. New developments should not be considered unless the developer is willing to pay the entire cost of water importation, such water coming from either Turkey Creek or Bear Creek. For the purposes of the District's planning, the recommended values in column 1 should be used for designing pumps, storage tanks, and piping; however, the values of column 2 can be used for growth limitations.

TABLE IV-A

MONTHLY DESIGN VALUES FOR WATER CONSUMPTION

Month	Typical Area Gallons per Month per EQR	Indian Hills, Recommended Gallons per Month per full-time EQR 1	2
January	9,000	7,500	7,000
February	9,000	7,100	7,000
March	9,000	7,500	7,000
April	10,000	7,500	7,000

TABLE IV-A (Continued)

Month	Typical Area Gallons per Month per EQR	Indian Hills, Recommended Gallons per Month per full-time EQR 1	2
May	18,000	9,000	7,000
June	24,000	10,000	7,000
July	26,000	12,000	7,000
August	24,000	12,000	7,000
September	18,000	11,000	7,000
October	15,000	9,000	7,000
November	9,000	7,500	7,000
December	9,000	7,500	7,000
Total Year	180,000 gal/yr.	107,600	

Criteria for groundwater development would follow the recommendations for exploration and locations described in the Dr. David T. Snow Report, Appendix A.

Water Quality. Groundwater, such as from the alluvium of Parmalee Gulch must receive disinfection before use in the domestic water system. Minimum water quality design criteria must be in accordance with Colorado State Standards for bacteriological, physical, and chemical standards. Allowable bacterial densities in the finished water are prescribed by the State Health Department. Design criteria should assume that no live pathogenic bacteria or viruses can be present in the finished water. Limiting chemical concentrations are given in Table IV-B.

TABLE IV-B

WATER CHEMICAL QUALITY CRITERIA

(As established by the Colorado State Department of Public Health)

Substance	Maximum Allowable Concentrations in Parts per Million, Unless Noted
Group 1 - Mandatory Limits	
Arsenic	0.05 (0.01 recommended)
Barium	1.0
Cadmium	0.01
Chromium (Hexavalent)	0.05
Cyanide	0.2 (0.01 recommended)
Lead	0.05
Selenium	0.01

TABLE IV-B (Continued)

Substance	Maximum Allowable Concentrations in Parts per Million, Unless Noted
Silver	0.05
Turbidity	5 units
Color	15 units -- cobalt scale
Group II - Recommended Limits	
Alkyl Benzyl Sulfonate	0.5
Chloride	250
Copper	1.0
Carbon Chloroform Extract	0.2
Iron	0.3
Magnesium	125
Manganese	0.05
Nitrate	45
Phenols	0.001
Sulfate	250
Total Dissolved Solids	500
Zinc	5

Water quality in Indian Hills is marginal, but with proper development, new wells should not exceed State Department of Health criteria. Watershed control requirements should be followed for two reasons:

1. The present water supply cannot support additional growth.
2. Potential contamination from septic systems and livestock.

Distribution System. The distribution and storage system design criteria for an area depend a great deal on the degree of fire protection to be afforded an area. Presently, the District is being protected by a rural-type fire department, and this has a great deal of merit. Due to the limited amount of water in the basin, a full municipal system is not feasible without the importation of water. Also, the Alpine Village water system does not meet the requirements of a municipal system.

Under these conditions, we recommend that "domestic-only" distribution system design criteria be adopted. There will still be some residual fire flows available most of the time, but it would not be the intent to furnish fire flow demands from the water system.

All pipelines should be sized hydraulically to furnish required peak domestic demands. Piping must conform to applicable standards as to strength and non-toxic qualities.

The new distribution system should all be designed to provide all-year water service. In areas where earth cover is sufficient, pipelines should have 5 feet minimum cover (6 foot desirable). Anti-freeze techniques should be incorporated into the proposed system. Service lines should be buried at least 6 feet deep and hydrants should be installed with pitorifices or service taps. Due to the limited water availability, bleeding to prevent freezing should not be allowed under any circumstances. Where adequate earth cover is not available, special design techniques will be required to prevent freezing. Meters should be installed on each service line and the Rules and Regulations should reflect control of individual water use.

Distribution system pressures should be controlled with suitable pressure reducing valves to form pressure zones ranging generally between 25 and 100 psi under normal operating conditions. In certain locations, the limiting pressure criteria may be exceeded to eliminate excessive cost from line duplication. Individual pressure reducing valves are recommended on building services where normal pressures exceed about 90 psi. Main line pressure relief valves should be used to protect against pressure rises resulting from malfunctioning pressure control valves.

Storage. Normal criteria for a domestic-use system would indicate a volume equal to one day's water use for the District. This criterion would result in 70,000 gallons of storage at Indian Hills. Since water supply will limit the number of customers, it can be assumed that the maximum possible number that the system can support will be eventually connected. Considering the vulnerability of this type of system to power outages and service disruptions, we would recommend that approximately 200,000 gallons of storage be phased into the system at ultimate development.

The clear water storage reservoirs should be aesthetically compatible with their surroundings, which would mean screening and/or buried reservoirs.

For reliability, some storage should be distributed through the District rather than concentrated. To attain minimum pumping costs, it is desirable to locate storage in each pressure zone in proportion to the number of users. The latter criterion is difficult to satisfy in Indian Hills.

MASTER PLAN

The system recommended in this Report has been developed to meet interim and long-range requirements. There is flexibility as to the phasing of facilities to meet District needs (Alternate Program 2 or 3). The Master Plan is described hereinafter by functional unit; however, each unit must be regarded as an integral part of a comprehensive plan. Capital cost estimates for all recommended improvements are furnished.

Water Rights.

1. Obtain appropriate legal opinions on water rights owned by the District, and the need for direct flow water rights in the future, considering strict administration under the Appropriation Doctrine.
2. Prepare a detailed water rights-engineering analysis to relate the need and use of water by the District to specific irrigation water rights. Select water rights to be sought.
3. Retain a real estate agent to option or acquire water rights.
4. The water rights acquired would be studied, and an application made to the Water Court at Greeley for a change in point of diversion. It should be expected that in the range of one-third

of the rights would be lost in the transfer proceedings. The proceedings should be designed to result in a useable transferred withdrawal rate of approximately 0.25 cfs.

5. It is believed that the Hodgson, Warrior, and Pioneer Union Ditches would be most suitable for the District.

Water Supply. The estimated physical yield from the Parmalee Gulch basin will support about 250 full-time equivalent residential taps. This would be insufficient if the approximately 350 existing taps in the drainage basin all changed character to full-time use. It is apparent that definite steps should be taken to preserve the existing water supply, develop additional water from within the basin, and control growth -- including the drilling of new individual wells and the operation of existing individual wells. In our opinion, the developable supply should prove adequate if the use mix does not exceed about 50% full-time residential.

The primary water supply would be developed using Well No. 5 of the existing system and establishing five new wells in the locations shown in the Dr. Snow Report. Of these, Well Nos. 1 and 2 would be developed first. Well Nos. 3 and 4 are located near developed areas which have their own wells and operate their own systems. It is possible that it will not be feasible to establish these latter wells where they are shown. If not, Dr. Snow should investigate alternate locations and make recommendations to the Board. It should be pointed out that it will take all of these wells to develop the estimated yield of this basin.

Additional water may be available by recycling, and it may definitely be necessary to recycle water if the District is required by law to serve undeveloped land in the District when that land develops. To recycle water, a well would be installed in the lower portion of Parmalee Gulch to catch part of the return flow water from septic systems.

This water could be de-nitrified and pumped to be mixed with virgin water in the new storage reservoir above Alpine Village (See Drawing No. 2). It is not recommended that a central sewage system be built in the Parmalee Gulch basin unless a decision is made to import water to the basin. From water quality reports showing high nitrate content in some wells, it is apparent that the District is presently practicing some water recycling. Experience will probably indicate that some of the other existing wells should be later refurbished for standby water supply.

Distribution System. The proposed distribution system improvements are shown on Drawing 2. The distribution system has been divided into three basic pressure zones and the "blue-lines," or elevations denoting dividing lines between areas of higher and lower pressures are shown in Table IV-C. In certain areas it is necessary to allow higher pressures to avoid wholesale duplication of piping and to allow for easier operation. Pressure reducing valves (PRV) are used to lower the pressure from zone to zone.

TABLE IV-C
PROPOSED PRESSURE ZONES FOR INDIAN HILLS

Pressure Zone	Service Area Upper Elevation
Lower	7520
Middle	7310
Upper	7080

The present practice of metering service lines should be continued and pressure reducing valves should be installed on services at locations where the District static head would exceed 90 psi. Small capacity fire hydrants generally should be installed at about 2,000 foot intervals, but more frequent spacing may be desirable for certain areas. The primary purpose for the hydrants is to fill tank trucks; however, in some instances, hydrants could supply small, direct fire streams.

There will be lack of looped lines in the system, due primarily to cost considerations. The widely dispersed wells and storage for the District will help alleviate the lack of reliability that results from an unlooped system.

The Unique Design procedures recommended to reduce costs yet still provide for year-round service are described following in general order of preference.

- For all areas where the earth mantle is adequate, pipelines will be buried with 5-foot to 6-foot cover. These lines can be left in service without significant probability of freezing. Individual services off these lines must also be installed with 6-foot cover.

- For rock areas (expensive excavation), and where near continual water flow, or circulation, can be provided, lines would be insulated and installed as deeply as possible. Minimum cover about one foot.

- For rock areas where circulation is not likely, lines would be insulated and installed on a continually sloping grade. Residents who want winter service would be required to maintain a tank with booster pump. Periodically, the District would activate the shallow distribution lines, fill the tanks, and then drain the lines to prevent freezing. Individual storage tanks would not have to be for large (preferably 1 week's) requirements. Hopefully, these customers would mostly be ones who already have installed cisterns.

Storage. Several storage reservoirs totalling 200,000 gallons (ultimate) are to be installed for the District at the approximate locations shown on Drawing No. 2. The smaller tanks as well as the 100,000 gallon reservoir should be buried if possible. Because of cost factors, the 100,000 gallon reservoir could be installed on the surface, though burying it would improve aesthetics.

Based on criteria set forth in this Section, a total of 200,000 gallons of storage should be provided for basic supply. As shown, about 120,000 gallons is provided in initial development with the additional 80,000 gallon reservoir to be installed after income and need warrant additional storage. The 100,000 gallon tank should be located higher than the existing 35,000 gallons of storage in Alpine Village to eliminate the small pumping station now in use.

PRELIMINARY COST ESTIMATE

Following is a preliminary capital cost estimate for facilities proposed by the Master Plan. Costs are based on 1972 anticipated levels with a 5% inflation allowance. Later construction estimates should be revised to reflect then current dollar values.

A 25% allowance has been added to the estimated contract cost. This is a normal allowance intended to cover:

- Contingencies - problems occuring before final design and construction, not forseeable at this time.
- Surveys
- Design engineering
- Legal, fiscal, administrative expense
- Construction inspection
- Other miscellaneous project costs

The estimate has been broken into three time phases. The first includes what is considered to be a minimum initial capital investment needed now to protect the District. The second is a recommended capital program intended for near-future implementation in order to result in a good quality all-year water system. The third portion includes projected improvements required by the Master Plan, but not thought necessary under the first program.

TABLE IV-D

PRELIMINARY COST ESTIMATE

1. MINIMUM PROGRAM

Water Rights	$15,000	
Wells 1 & 2 (New)	20,000	
Improve Wells 2 & 5 (existing)	10,000	
4'' DIP - 500 l.f.	2,750	
3'' PVC - 1,900 l.f.	7,600	
1½'' PVC - 750 l.f.	1,850	
1'' Copper - 800 l.f.	2,400	
Hydrant - 1 each	400	
Move & Install 2 - 10,000 gal. tanks	3,000	
	$63,600	
Plus 25% contingencies	16,000	
Total - Minimum Program		$ 79,000

2. RECOMMENDED PROGRAM (Items in addition to minimum program.)

1'' PRV - 1 each	$ 300	
3'' PRV - 3 each	10,500	
100,000 gal. buried reservoir	45,000	
4'' DIP - 4,500 l.f.	24,800	
3'' PVC - 9,350 l.f.	37,400	
3'' PVC (insulated) - 1,600 l.f.	8,000	
2'' PVC - 11,600 l.f.	34,800	
1½'' PVC - 850 l.f.	2,200	
1¼'' Copper (insulated) - 1,750 l.f.	6,200	
1'' Copper (insulated) - 3,550 l.f.	10,600	
1'' Copper - 1,200 l.f.	2,400	
3/4'' Copper (insulated - 1,300 l.f.	3,200	
3/4'' Copper - 800 l.f.	1,200	
Drains - 2 each	500	
Hydrants - 5 each	2,000	
	$189,100	
Plus 25% contingencies	47,300	
Total of Additional Facilities		$236,400
TOTAL RECOMMENDED PROGRAM (ITEMS 1 & 2)		$315,400

3. <u>FUTURE MASTER PLAN IMPROVEMENTS</u>

80,000 Gallon Reservoir	$40,000	
Wells 3, 4, & 5 (New)	30,000	
2'' PVC - 650 l.f.	2,000	
1½'' PRV - 3,900 l.f.	9,800	
	$81,800	
Plus 25% Contingencies	20,400	
Total of Future Improvements		$102,200
TOTAL ESTIMATED MASTER PLAN - CAPITAL COSTS (for existing development)		$417,600

APPENDIX A

REPORT TO THE

INDIAN HILLS WATER BOARD

Concerning

FUTURE HYDROLOGIC STUDIES FOR INDIAN HILLS

JEFFERSON COUNTY, COLORADO

David T. Snow

February 16, 1971

This report is to assess what has been done and to discuss what should be done for the benefit of the water resources of Indian Hills. This is more of a tentative conception of a planning program, rather than an authoritative, exhaustive analysis. The latter could be years down the road, the product of numerous contributors.

The discussion follows four headings, believed to be threats to the adequacy of the Indian Hills water supply: 1) over-demand on the system by increased population, 2) drought, 3) appropriation of water rights and 4) pollution. There can be no doubt that a modest investment in a systematic study of matters bearing on these topics will reap inordinate benefits to the community in coming years. It is hard to define the point of diminishing returns for such endeavors, but since paper studies are cheap compared to wells, pumps, pipes, tanks and watershed lands, it should become policy to finance continued studies to the greatest extent the Water District can afford as investments.

1. Demand on the System

There is no suggestion that the existing supply is inadequate in quantity, but if population growth and water reserves are unknown, no statement of future adequacy can be made. To this end, the 1970 census and statistical projections should be studied. A measure of extreme utilization would be obtained by map study of the total developable watershed, subdivided according to present county zoning regulations. A professional land developer could make a more realistic estimate of the ultimate population within the distribution system.

The present rate of consumption per capita should be estimated, by measurement of pumpage, directly or indirectly. Seasonal fluctuations of demand are pertinent.

The current reserves cannot be conservatively measured by the proportion of the day the pumps don't operate, simply because down-time is probably important for water-level recovery in the well and surrounding ground. Nevertheless, an estimate of additional capacity can be made from a week's log of pumpage and water levels, given characteristics of the pump, well and aquifer. Due consideration must be given to each neighboring well that might be adversely effected by greater drawdown of the public wells, and the limitation that such interference may have on the allowable yields. The question must be answered: "Are the existing alluvial wells going to remain serviceable, or will water quality deteriorate?". If present supplies could conceivably be condemned, the resources would diminish to the remaining wells which are largely in a speculative stage of development.

The well supplies, as discussed in the companion report, may be added to the inventory of system resources as they are drilled and adequately pump-tested. Due allowance must be made for long-term drawdown effects in assessing yields. Certain existing private wells may have excess capacity possibly useful to the water district. Purchase of water or wells may be considered after inquiry and tests.

2. Drought Conditions

Resources reach a low point when normal climatic variations impose drought conditions, sometimes during a succession of years. Water supplies can be drastically reduced to a fraction in such times because fractured rock and shallow alluvium have limited storage capacity, easily depleted if no periodic recharge occurs. Expectation may be based on 1) Evergreen precipitation records, giving a recurrence rate for droughts, and possible precipitation for drought years; 2) Testimony of residents of Indian Hills during the 1963 drought, or earlier events, noting water-table depression in rock wells, faults and alluvium; 3) Dendrochronology, the interpretation of tree rings, can furnish a long record of drought occurrence, far better than a few decades of meteorologic record. To quantify resources in drought, the yield of remaining wells still drawing water may be estimated from present-day well performance, so that total system supply can be estimated.

Contingency plans should be drawn. Locations of well sites should be identified in advance, so that emergency wells can be drilled on need. For example, a fault zone penetrated at shallow depth by a new well, say in 1971, may then be located with more precision, so that a deeper penetration could be made when lower water tables prevail. Water rationing procedures may be designed for continued use of the distribution system in times of low supply.

3. Appropriation

Legal counsel is needed to provide definition of conditions under which water may be lost to other claimants, presumably in competition by other domestic users, as opposed to irrigation users. How must domestic status be defined? Can any lawn watering be risked? Among water wells of Indian Hills, the public wells should establish first rights, by earliest claim. All other wells should also establish right, to protect all interior resources, for if others lose rights, the demand will fall on the public system.

In the event of claims, that flow to Turkey Creek is diminished by well withdrawals in Indian Hills, the defense, is possible, would rest on proof that such withdrawals have not and do not diminish discharge of Parmalee Gulch. A periodic, representative record of stream flow near the mouth must be maintained. Past history should be documented as well as possible. One of various types of channel control structures, such as a weir, should be built, with a staff gage for recording water level and for calibrating discharge over the control.

The Floyd Hill fault zone may be tributary to Turkey Canyon. If well discharge from the fault does not decrease the outflow, it can be documented by an observation well in the fault zone upslope of Turkey Creek, say on the slope in Sec. 16. Whereas all wells will probably fall in droughts, when claims are most likely, a record indicating that there is no fall of the observation well during normal times would help establish that a drought-period fall is of natural causes.

The more the watershed is developed for domestic use, without lawn irrigation, the more likely it may be that the discharge of Parmalee Gulch may increase. By drawing down the water table around wells covering much of the watershed, plant use or evapotranspiration will diminish. Domestic water is efficiently returned to the groundwater below the soil zone by leach-field tiles. Areas of perrenially wet conditions (eg. Schaus' meadow) may yield large net increases of supply by dewatering them by wells. If the history of stream discharge is demonstrably increasing over the years, a claim of downstream damage can be defended.

4. Pollution

Existing wells could be condemned in the event of consistently inadequate quality, throwing the burden on remaining water supplies. If contamination is from leach-field effluent transmitted underground, the contamination could be prolonged. Contamination via surface water is temporary, if the cause can be rectified by proper well construction or by stopping issues from nearby faulty leach-fields or corrals. The report of the Colorado Department of Health finds certain rectifiable inadequacies in well construction, but cites hazardous locations as detriments to some wells. It may be practical to retire such wells from the system, holding them in reserve instead of making immediate repairs, provided that new water sources are developed elsewhere, as suggested in the companion report. New wells, thoroughly tested, would serve as insurance against future loss of any wells now in the system, whether the loss is by reason of water quality or water quantity. As greater populations move upstream of the existing wells, the likelihood of contamination grows because more water will circulate through disposal systems, then the soil and back to the wells.

It is in the interest of public welfare, and the water district, to initiate an educational program for owners of other wells not part of the system. Literature or lectures on water quality, groundwater hydrology, well contamination and watershed management should be available to all, so stimulating some to protect themselves from hazards or even condemnation that would burden the water district's system.

Steps should be considered for assuring permanence of any newly-developed water resource: how best can contamination be assuredly prevented?

The implications of establishing watershed preserves should be weighed: can zoning be established in certain areas to exclude future house-building or pasturing animals, or must the district buy land to preserve its cleanliness? On Schaus' meadow, 40-50 acres of bottom land free from pollutents of human or animal origin would provide considerable opportunity for natural water purification in flowing from leach-fields nearby and upstream, through the soil and to any new wells or infiltration gallery. It may be too late to re-direct effluent from the dozen-odd residences on that watershed, but undeveloped forest-land upstream could be controlled in the same way as any other watershed. The watershed above Dr. Lowery's meadow has only one (summer ?) residence, and Giant Gulch, only two. Aside from the desirability of safeguarding groundwater supplies by preserving natural surface conditions, there could be developed surface storage ponds on these watersheds. Costly as land acquisition may appear, it should be weighed against the economic advantage to the rest of Indian Hills that would result from a water supply of assured permanence, based on a watershed preserve.

REPORT TO THE

INDIAN HILLS WATER BOARD

Concerning

UNDEVELOPED WATER RESOURCES OF INDIAN HILLS

JEFFERSON COUNTY, COLORADO

David T. Snow

February 16, 1971

The Board's action demonstrates a healthy appreciation of the fact that the community ground water supply depends on the hydrogeology of the watershed. Towards fuller realization of the potential water resources, the attached geologic map was prepared. Dr. C. L. Sainsbury is chief author of the map with contributions by the U. S. Geological Survey, Dr. David W. Trexler and the undersigned.

Though the map lacks detail in certain extremities of the watershed, it is sufficiently complete in areas geologically favorable for large-capacity wells. The higher elevations, underlain by bedrock that cannot store nor transmit significant groundwater are not worth detailed study at this time. The populous lower parts of the valley, especially along Parmalee Gulch, are not attractive for community well-water supplies because these parts are pre-empted by prior well ownership. If supplies are not now contaminated here, they will be largely contaminated later. Locations topographically favorable for wells are along the western edge of the valley.

A unique geological feature, leading to significent water prospects, is the Floyd Hill fault zone. As shown by the geologic map, the trace of the fault zone is through Dix Saddle, southeastward through Indian Hills to Turkey Creek. The zone is probably a steep south-west dipping, irregular planar feature whose variable width locally attains as much as 200 feet. The materials in the zone, as suggested by exposure on the north bank of Bear Creek at Kittridge, and by partial exposures in roadcuts in Indian Hills, consist of intensely brecciated gneissic granite, and some gougey sheared schist.

The yield of water to a well completed in the fault zone will depend on several factors, some predictable or controllable by judicious installation, others unpredictable and chance. Since such a zone serves as a storage vessel for water between times of greatest withdrawal, as well as a conductor of water from its more remote parts, performance is influenced by 1) the width of the zone, 2) the coarseness of the fault breccia and 3) the relative absence of fines in the zone, markedly influencing ability to supply large volumes. Unfortunately, natural exposures do not afford possibility of discriminating between differing parts of the zone. Trial drilling would be helpful for this purpose. The location of a well for 4) maximum intersection of the fault zone can be optimized in some places, but only guessed at in other places where the zone is ill-defined in location or attitude. Recognizing the practical necessity for vertical wells rather than the more resourcefully inclined wells that would cut the fault zone more certainly, it is suggested that trial holes be drilled at any fault zone well site until satisfactory unconsolidated materials are encountered to about a hundred feet in depth. If a percussion drill encounters much hard rock at shallow depth, say before 50 ft. depth, then the rig should be moved about 50 ft. across the fault zone for a subsequent probe. If 5) the surrounding topography slopes toward the well site, the discharge and storage conditions are optimized. Places where the fault zone crosses NE-flowing streams tributary to Parmalee Gulch are therefore preferable to saddle-like topographic sites. 6) Proximity to sources of water that can recharge the fault aquifer by infiltration will influence the long-term yield at any well site. A system containing large storage volume can sustain temporary overdraft (falling water-table) conditions provided eventual recharge occurs to restore the water. These conditions are met most reliably where streams cross the fault zone. 7) Freedom from hazard of water quality deterioration is best obtained by avoidance of sites downslope of habitations. The requirement is largely inconsistent with criterion number 5, and suggests that the powers of the Board be exercised to prevent man-made hazards from developing in the future. The "water preserve" concept should be considered. 8) Freedom from sources of natural water contamination can be avoided when and if mineral deposits suggest poor water. There will remain the possibility that such constituents as high sulfate content may be encountered in spite of a total lack of surface evidence prior to drilling. The fault zone environment is particularly prone to natural mineralization. 9) The ability of clays to filter, absorb and oxidize deleterious matter from infiltrating surface water or leach-field effluent is not ideally provided by either fractures or faults in bedrock. Even a deeply-weathered fault zone is probably inferior to alluvium, the clays, sand, gravels and carbonaceous matter present along some stream courses such as Parmalee Gulch. Favorable alluvial sites should be given priority because of uncertainty of fault-zone yields and other possible disadvantages discussed above. The first and second preferred well sites are accordingly located in the meadows of Schaus and Lowery, respectively. These amount to "a bird in hand," compared to the fault zone sites (#3 to 5) indicated later in this report.

Schaus' meadow, NE 1/4, Sec. 7, is now (January 28-30) discharging about 20 gpm at the confluence with Parmalee Gulch. It also transpires about 15 gpm from the saturated meadow surface. The water yield is apparently greater per acre of watershed than any other tributary to Parmalee Gulch, perhaps because of seepage emerging from the Floyd Hill fault, which crosses the head of the meadow. There is one flowing well (or developed spring) in the meadow 100 yards from Schaus' house, flowing about 5 gpm. Additional water emerges farther downslope. That which doesn't evaporate runs to Turkey Creek, but a goodly water supply could be developed by prevention of evapotranspiration loss by lowering the water-table throughout the meadow. Until year-round discharge data are available, the potential dry-season water yield can be estimated at 10,000 gallons per day, with the possibility of a 20,000 gpd dry-season yield and a 40,000 gpd wet-season yield. A system of wells, or infiltration galleries and tile drains is feasible if the alluvium is shallow. The meadow can be explored at small expense with a power auger, so an infiltration system may be designed. One possibility is a gallery, dug with a backhoe to bedrock across the valley and backfilled with gravel. It would produce far greater flows and provide much greater storage than any well. The meadow could be developed from the lowest property acquireable, but no lower than the uppermost tributary leach-fields. Subsequent additions to the system may be made further upslope, either to augment flow or dewater the surface. In any event, the meadow and immediate surroundings should be cleared of all human and animal uses as a groundwater preserve. If auger-drilling discloses clayey alluvium, it is likely that shallow wells cannot develop the full yield of the valley, as a cut-off gallery should do. If clean gravel is found, a multiple-well field might be installed as demand grows. The alluvium may be partly mudflow material, thus bouldery.

The meadow upstream of Dr. Lowery's residence, SW 1/4, Sec. 8, is the second-priority site, underlain by alluvium probably similar to that in Schaus' meadow, suggesting the possibility of coarse fill effectively draining to Parmalee Gulch, or small recharge from the stream, or loss to the Floyd Hill fault zone. Test-hole drilling with a power auger is recommended to precede well or gallery installation, to be designed subject to exploration results. The setting is similar to Schaus' meadow insofar as its watershed is also of about one section, largely of underdeveloped land; the meadow is crossed by at least one fault zone contributing to the hydrologic resource. The site is second priority because the water resource is less obviously certain, and its elevation is below that of Shaus' meadow, thus costs more in pumpage.

Exploration should proceed from the lower end toward the upper: greater storage could be obtained by withdrawing at the downstream end. A pegmatite, (often fractured), might be tapped beneath the valley alluvium. Failing to find adequate yields when pump-tested, an alternative possibility would be to seek the fault zone beneath alluvium, located somewhere near the west end of the alluvial valley, as shown on the geologic map. A well perforated in the alluvium only may prove productive enough, but the underlying bedrock aquifers mentioned should be targets of the same well(s). The predicted minimum yield, based only on geologic setting and recharge, is 7,500 gallons per day, though several times this rate may be realized if favorable conditions are encountered. No other site is as favored to provide uncontaminated water, since its large watershed is essentially undeveloped (except one summer home).

The third-priority site is at the mouth of Giant Gulch, where a high-discharge well might be developed in fault-zone material. The entire valley area there may be intensely shattered and decomposed, near the intersection of two faults. Since the detailed structure is concealed by soils, an auger-hole exploration is also adviseable preliminary to well-drilling. Any site near the creek would induce recharge upon drawndown in the alluvium and fault zones, and would benefit from fault zone storage. Giant Gulch is the largest and perhaps most reliable recharge source of any tributary to Parmalee Gulch. Unfortunately, no alluvium nor fault-zone storage is available upstream of the developed homes, whereas contamination is inevitable at well sites in, or east of the fault (roughly at the road crossing). The minimum yield estimate is placed at about 5,000 gallons per day. The alluvial storage is of small volume, so yields will depend greatly on the character of the broken faulted bedrock material. There are posibilities of greater yields than the estimated minimum.

The fourth-priority well site is adjacent to the drainage by Gilmore Chapel, in the alluvium and fault zone. Recharge is less favorable than at the first three sites suggested, because of the watershed size. Alluvial storage is enhanced by positions downstream on the drainage, but so is the hazard of contamination. Further upstream, as at the well now operating just west of the uppermost road, there is only fault-zone material to tap, but water quality may be superior. The existing wells in the valley should be tested adequately by prolonged pumping because potential yields have probably not been realized by the owner. The present estimate of minimum yield is 5,000 gallons per day, with possibility of more.

The fifth-priority site lies about 1,000 feet upstream and north of Parmalee Gulch in the NW 1/4, Sec. 16. A fault zone dipping steeply SW cuts the drainage, which shows increased flow at that place. A well should penetrate the hanging wall of the fault at about 100 ft. depth. No alluvium is present. The minimum yield prediction is about 4,000 gallons per day, and upwards. The watershed is essentially undeveloped, nor is there any current threat of contamination of waters in the fault zone.

Bonafide alluvium is not abundant in the Parmalee Gulch watershed. Wells of high yield (say 10 gpm or more) are now developed by the Water Board and others, but these wells and potential wells like them are not envisioned as the ultimate internal water supply for Indian Hills, because of the press of dense population on and above these alluvial deposits. The gently-rolling terrain of Alpine Meadows Subdivision, Dix Saddle and the valley through Camp Coy are not believed to possess transported alluvium of the sort that makes a good aquifer, but rather, clayey residual soil and colluvium. There is already a great deal of well-drilling experience gained in this area, most of which suggests very modest (1 gpm range) water yields. Though exceptional fault-zone wells could be located, there would be numerous failures drilled in the search.

There may be fault-zone well sites other than the five fault-related sites outlined above. The writer doubts the merits of any fault sites lacking an obvious recharge source. Thus Dix Saddle, or the saddle in the SE 1/4, Sec. 6, or on the slope in the SW 1/4, Sec. 16, should be counted in the category of supply for at most a few homes.

The appropriate steps toward securing for community use the possible resources of the five recommended sites should be a matter for the whole Board to determine. My comments, largely related to technical aspects of development, assume certain elements of feasibility, such as the goodwill of owners.

Certain existing wells should be checked before new wells are drilled. The canvass of wells completed revealed several whose yields may be of community interest.

1. At #8630 (Fire Control Map), Dr. Sainsbury's #3, is a well that once supported the mica mine and trailer court. It should be pump-tested.

3. Well #7440, Mr. Foley's #1, 10 gpm estimated. Check water quality, then pump-test. It lies close to (if not in) a mapped fault.

4. Well #5260, Mr. Foley's #12, 2 cfs reported (=900 gpm) at top of trailer court, possibly on fault zone. Check veracity, then quality, then pump-test.

5. Well #3308, reportedly 3 gpm, but probably on the fault zone and could be good for more than stated. Check veracity, quality, test.

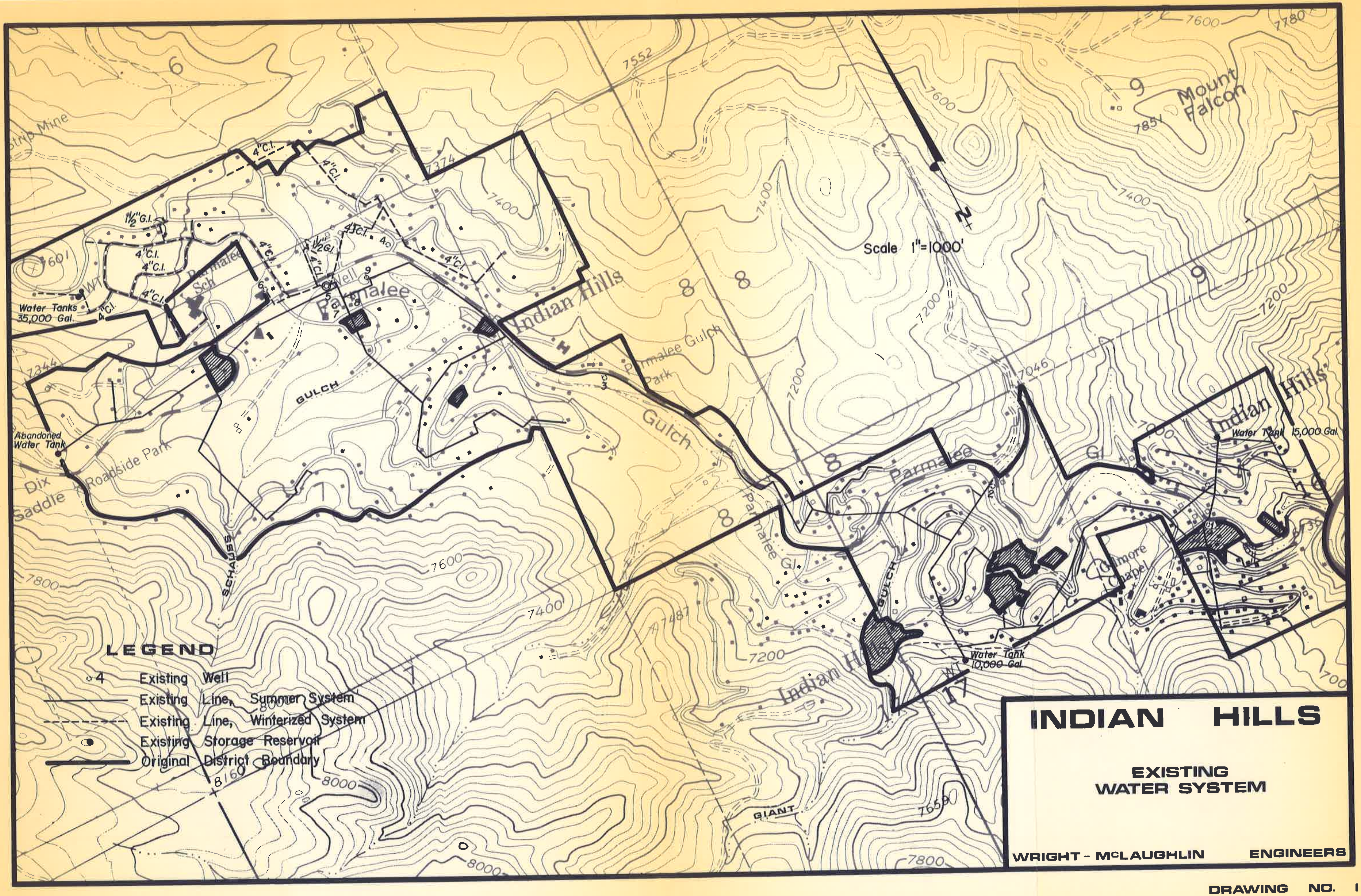
6. Well #3514, reported (Mr. King) at 20 gpm. There is a discrepancy between King's location, and the Fire Control location. Verify discharge, quality, test.

7. Well(s) #1000, Geneva Glen, 5 gpm reported. May be several wells. Verify each, test quality, then pump-test best, or uppermost well.

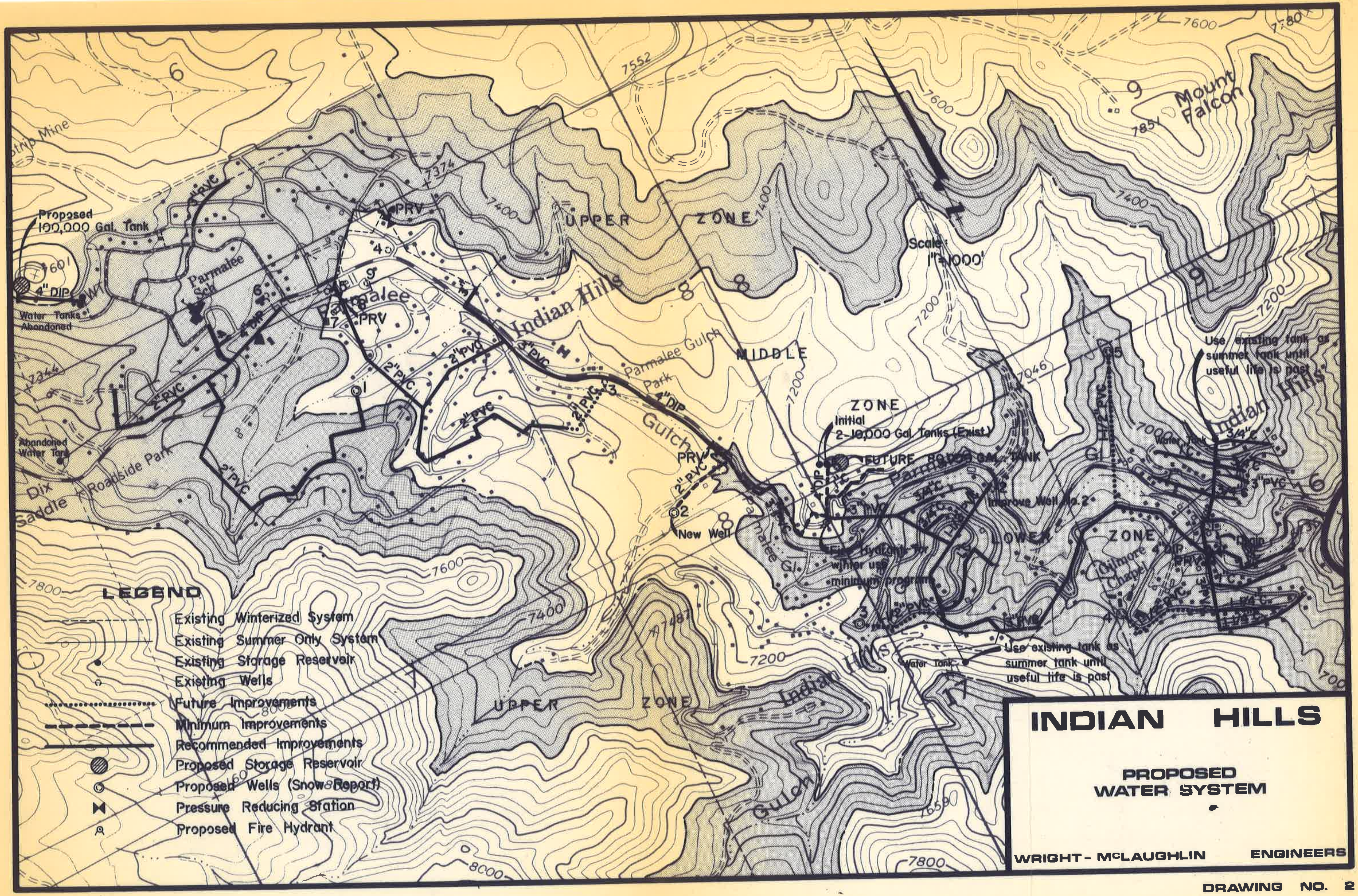
Good new wells could probably be installed at the five locations indicated on the geologic map, but the determination of the best well locations at sites 1 through 4 requires some exploration beyond what can be done by surface geology. There can be much benefit from a day's work with an auger rig, such as may be provided for $240. Fifteen to twenty-five exploration holes, some 10's of feet deep, as required, may be expected in that time. Well locations and possible seepage galleries may be designed according to the state of knowledge of subsurface conditions disclosed by 1 day's drilling supervised and logged by a geologist.

An important economic advantage of pre-exploration is the substitution of inexpensive soil-drilling techniques for the usual hard-rock footage quotations of well-drillers. Augering should disclose thicknesses of alluvium and penetration in broken, decomposed fault zones, where rapid water well drilling at hourly rates can give great advantage over rock-drilling rates by the foot. In alluvium, a 3 or 4 foot bucket auger can undercut and drive concrete pipe segments for dug wells, as much as 40 ft. per day. If alluvium is shallow but pervious, a collection gallery may be backhoed across a valley. The comparison with well costs will be possible after depths to bedrock have been determined by augering.

The order of development of sites now listed priority 1, 2, 3, and 4 might change upon completion of auger drilling. Other factors beyond the scope of this report will also become important to planning additions to the Indian Hills water district facilities.


INDIAN HILLS
EXISTING WATER SYSTEM
WRIGHT - McLAUGHLIN ENGINEERS
LEGEND
4 Existing Well
Existing Line, Summer System
Existing Line, Winterized System
Existing Storage Reservoir
Original District Boundary
Scale 1"=1000'
N
Mount Falcon
Strip Mine
Water Tanks 35,000 Gal.
Abandoned Water Tank
Dix Saddle
Roadside Park
Parmalee Gulch
Parmalee Gulch Park
Indian Hills
Water Tank 15,000 Gal.
Water Tank 10,000 Gal.
Gilmore Chapel
SCHAUSS
GULCH
GIANT
4"C.I.
1½"G.I.
WT
Well

DRAWING NO. 1


INDIAN HILLS
PROPOSED
WATER SYSTEM
WRIGHT - McLAUGHLIN
ENGINEERS
LEGEND
Existing Winterized System
Existing Summer Only System
Existing Storage Reservoir
Existing Wells
Future Improvements
Minimum Improvements
Recommended Improvements
Proposed Storage Reservoir
Proposed Wells (Snow Report)
Pressure Reducing Station
Proposed Fire Hydrant
UPPER ZONE
MIDDLE ZONE
LOWER ZONE
Scale: 1"=1000'
Proposed 100,000 Gal. Tank
Water Tanks Abandoned
Abandoned Water Tank
Initial 2-10,000 Gal. Tanks (Exist.)
FUTURE 80,000 GAL. TANK
Improve Well No. 2
New Well
Fire Hydrants for winter use minimum program
Use existing tank as summer tank until useful life is past
Mount Falcon
Indian Hills
Parmalee Gulch
Parmalee Gulch Park
Dix Saddle Roadside Park
Strip Mine
Parmalee Sch.
PRV

DRAWING NO. 2