Chino Valley

Area Drainage Master Plan Study

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2009716

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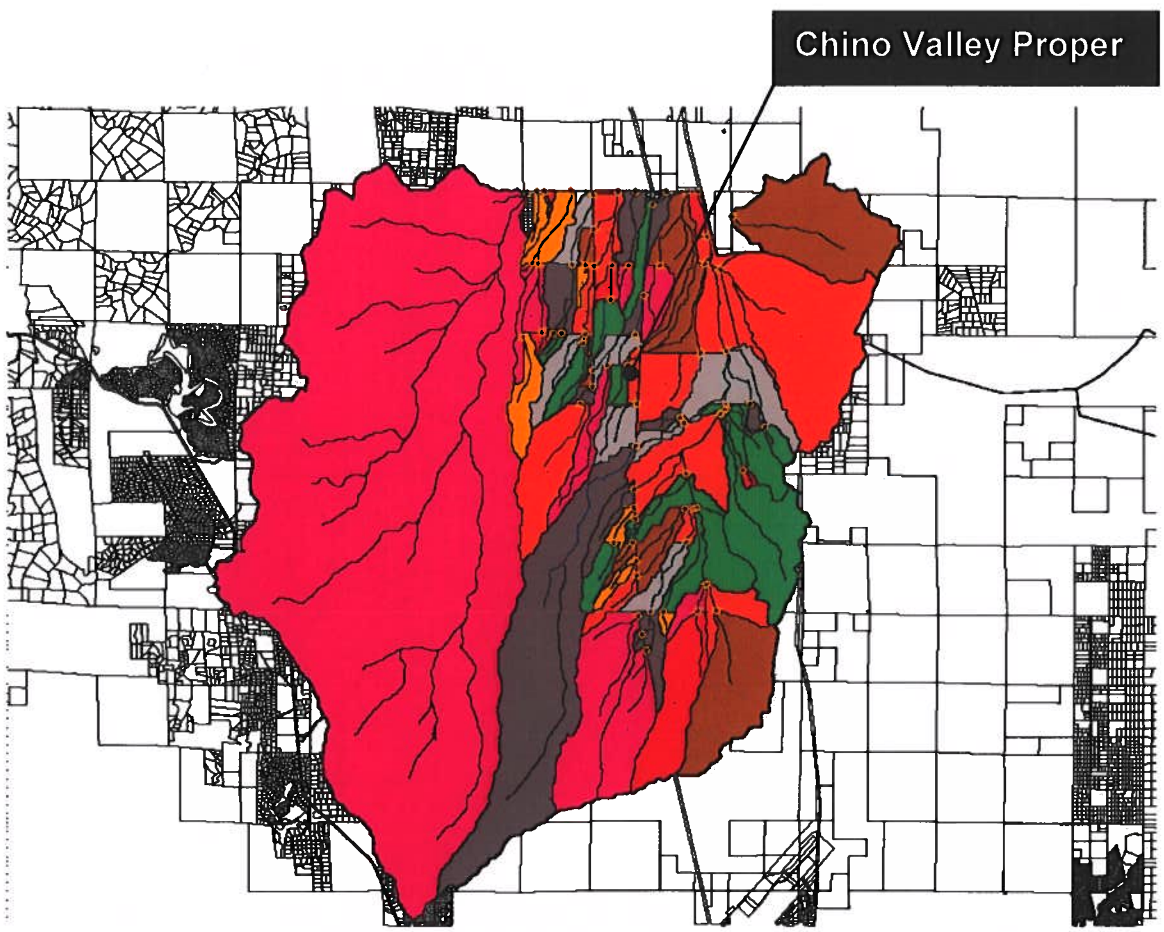
I. Introduction

This hydrology study was commissioned in March 2010 by the Chino Valley Public Works Department and Town Council.

The purpose of this study is to provide a hydrologic analysis of the watersheds impacting the various areas of the Town. Hydrologic data is to be used for an analysis of shallow and concentrated flow patterns within variously shaped existing channels within public and private properties in the Town. All hydrologic modeling for the study was completed in accordance with the *Arizona Department of Water Resources Flood Mitigation Section State Standard for Hydrologic Modeling Guidelines*, except as noted.

Figure 1. Study Area



II. Hydrologic Modeling

1. Rainfall-Runoff Model

The hydrologic modeling for the study was performed using WMS (Watershed Modeling System) Version 8.3. WMS uses a GIS based data processing framework for hydrologic modeling. HEC-1 was utilized for the hydrologic modeling. HEC-1 was developed by the United States Army Corps of Engineers Hydrologic Engineering Center. HEC-1 is a lumped parameter storm event model which simulates the surface runoff response of a watershed to precipitation by representing the modeled basin as an interconnected system of hydrologic and hydraulic components (stream channels and reservoirs). Hydrographs are produced at points of interest or concentration points. HEC-1 is included on the Federal Emergency Management Agency's (FEMA's) published list of accepted hydrologic models and is widely accepted throughout Arizona.

2. Drainage Basin Delineation

Data for the delineation of the drainage basins impacting the study area was obtained from recently flown topographic data for the Town, in combination with the United States Geologic Survey (USGS) National Map Seamless Server. The data set obtained from the Server includes Digital Elevation Model (DEM) data and corresponding USGS Quadrangle images. The DEM data is part of the National Elevation Dataset (NED). A 10 meter DEM was utilized for the modeling (grid points at a 10 meter spacing). Basin boundaries were defined based upon recently flown topographic data and elevation sets extracted from the DEM's.

The study area includes 74 drainage basins comprising 70 square miles of drainage areas. The basin boundaries and concentration points shown herein were established based upon review with Town staff and other consultants that will be modeling channel water surfaces. Please refer to the **Hydrologic Modeling Map** in the **Appendix** for the drainage basin delineations.

Table 1. Basin Drainage Area Data

Basin	Drainage Area (square miles)
100	2.49
200	0.14
201	0.67
202	0.37
203	3.77
204	0.73
205	0.08
206	1.14
207	0.14
208	0.08
209	0.02
210	0.51
211	1.67
212	1.24
213	0.10
214	0.17
215	0.03
216	0.31
217	0.45
218	0.04
219	5.37
220	0.12
221	0.27
222	0.09
223	0.93
224	0.06
225	0.11
226	0.42
227	0.17
228	0.36
229	0.41
230	1.92
231	1.37
232	0.30
233	0.23
234	0.13
235	0.04
236	1.03
237	1.79
300	0.81
301	0.36

302	0.13
303	0.15
304	0.40
305	0.10
306	0.25
307	0.04
308	0.07
309	1.21
310	0.54
400	0.15
401	0.23
500	0.32
501	0.12
600	0.46
601	0.27
602	0.43
603	0.02
604	0.07
605	0.11
606	0.07
607	0.23
608	0.36
609	0.27
610	0.13
611	0.26
700	0.40
701	0.03
702	0.43
703	0.05
704	0.51
800	0.03
900	0.14
1000	31.54
Total	**69.96**

3. Precipitation Data

Rainfall data for the study area was obtained from the National Atmospheric and Oceanic Administration (NOAA) Atlas 14. The data was obtained using NOAA's Hydrometeorological Design Studies Center Precipitation Frequency Data Server.

The 70 square mile drainage study utilized 9 point rainfall positional values representing various elevations in the model. These 9 points were then averaged to result in 3 rainfall regions. Points 1, 2 and 3 were used to represent precipitation characteristics in the western hilly region. Points 4 and 5 were used to represent the Chino Valley proper vicinity, and points 6-9 were used to represent the eastern hilly region of the model.

Table 2. Basin Precipitation Data

Chino Valley ADMS Precipitation Depth Values

2 Year Return Frequency

Point	5 min	15 min	60 min	120 min	180 min	360 min	720 min	1440 min
1	0.29	0.55	0.92	1.05	1.11	1.31	1.56	1.74
2	0.29	0.56	0.93	1.07	1.13	1.33	1.59	1.8
3	0.3	0.57	0.95	1.08	1.15	1.35	1.64	1.9
Avg.	*0.29*	*0.56*	*0.93*	*1.07*	*1.13*	*1.33*	*1.60*	*1.81*
4	0.29	0.54	0.91	1.02	1.08	1.27	1.53	1.69
5	0.29	0.55	0.92	1.04	1.1	1.3	1.55	1.74
Avg.	*0.29*	*0.55*	*0.92*	*1.03*	*1.09*	*1.29*	*1.54*	*1.72*
6	0.29	0.55	0.92	1.05	1.1	1.31	1.56	1.78
7	0.29	0.55	0.91	1.02	1.09	1.28	1.55	1.73
8	0.29	0.55	0.91	1.03	1.09	1.27	1.54	1.72
9	0.29	0.55	0.91	1.03	1.09	1.28	1.54	1.74
Avg.	*0.29*	*0.55*	*0.91*	*1.03*	*1.09*	*1.29*	*1.55*	*1.74*

10 Year Return Frequency

Point	5 min	15 min	60 min	120 min	180 min	360 min	720 min	1440 min
1	0.48	0.92	1.53	1.68	1.73	1.94	2.24	2.54
2	0.49	0.92	1.53	1.71	1.74	1.97	2.28	2.62
3	0.5	0.94	1.56	1.72	1.77	2	2.35	2.77
Avg.	*0.49*	*0.93*	*1.54*	*1.70*	*1.75*	*1.97*	*2.29*	*2.64*
4	0.47	0.9	1.49	1.64	1.67	1.88	2.17	2.46
5	0.48	0.91	1.51	1.67	1.7	1.92	2.21	2.53
Avg.	*0.48*	*0.91*	*1.50*	*1.66*	*1.69*	*1.90*	*2.19*	*2.50*
6	0.48	0.91	1.52	1.68	1.71	1.93	2.23	2.59
7	0.48	0.9	1.5	1.63	1.68	1.88	2.21	2.51
8	0.48	0.9	1.5	1.64	1.68	1.88	2.19	2.5
9	0.48	0.91	1.51	1.65	1.69	1.89	2.2	2.52
Avg.	*0.48*	*0.91*	*1.51*	*1.65*	*1.69*	*1.90*	*2.21*	*2.53*

25 Year Return Frequency

Point	5 min	15 min	60 min	120 min	180 min	360 min	720 min	1440 min
1	0.61	1.15	1.91	2.1	2.12	2.35	2.65	3.01
2	0.61	1.15	1.92	2.12	2.14	2.39	2.69	3.11
3	0.62	1.17	1.95	2.14	2.17	2.43	2.77	3.29
Avg.	*0.61*	*1.16*	*1.93*	*2.12*	*2.14*	*2.39*	*2.70*	*3.14*
4	0.6	1.12	1.87	2.04	2.06	2.27	2.56	2.92
5	0.6	1.14	1.9	2.08	2.09	2.33	2.61	3.01
Avg.	*0.60*	*1.13*	*1.89*	*2.06*	*2.08*	*2.30*	*2.59*	*2.97*
6	0.61	1.14	1.91	2.09	2.1	2.34	2.63	3.08
7	0.6	1.13	1.89	2.03	2.06	2.28	2.6	2.98
8	0.6	1.13	1.89	2.04	2.06	2.28	2.59	2.97
9	0.6	1.14	1.89	2.06	2.08	2.29	2.6	3
Avg.	*0.60*	*1.14*	*1.90*	*2.06*	*2.08*	*2.30*	*2.61*	*3.01*

50 Year Return Frequency

Point	5 min	15 min	60 min	120 min	180 min	360 min	720 min	1440 min
1	0.71	1.34	2.23	2.44	2.46	2.69	2.97	3.38
2	0.71	1.34	2.23	2.47	2.49	2.73	3.02	3.49
3	0.72	1.36	2.27	2.49	2.52	2.77	3.11	3.7
Avg.	*0.71*	*1.35*	*2.24*	*2.47*	*2.49*	*2.73*	*3.03*	*3.52*
4	0.69	1.31	2.19	2.37	2.38	2.6	2.87	3.28
5	0.7	1.32	2.21	2.42	2.43	2.66	2.93	3.38
Avg.	*0.70*	*1.32*	*2.20*	*2.40*	*2.41*	*2.63*	*2.90*	*3.33*
6	0.71	1.33	2.22	2.43	2.44	2.67	2.95	3.46
7	0.7	1.32	2.2	2.37	2.39	2.61	2.92	3.34
8	0.7	1.32	2.2	2.38	2.39	2.6	2.9	3.33
9	0.7	1.32	2.21	2.39	2.41	2.62	2.91	3.37
Avg.	*0.70*	*1.32*	*2.21*	*2.39*	*2.41*	*2.63*	*2.92*	*3.38*

100 Year Return Frequency									
Point	5 min	15 min	60 min	120 min	180 min	360 min	720 min	1440 min
1	0.82	1.54	2.57	2.81	2.83	3.05	3.3	3.75
2	0.82	1.54	2.58	2.84	2.86	3.1	3.36	3.88
3	0.83	1.57	2.62	2.87	2.9	3.14	3.45	4.12
Avg.	*0.82*	*1.55*	*2.59*	*2.84*	*2.86*	*3.10*	*3.37*	*3.92*
4	0.8	1.52	2.53	2.74	2.74	2.95	3.18	3.65
5	0.81	1.53	2.55	2.79	2.79	3.02	3.25	3.76
Avg.	*0.81*	*1.53*	*2.54*	*2.77*	*2.77*	*2.99*	*3.22*	*3.71*
6	0.81	1.53	2.56	2.8	2.81	3.04	3.28	3.85
7	0.81	1.53	2.54	2.73	2.75	2.96	3.24	3.72
8	0.81	1.52	2.54	2.74	2.75	2.95	3.21	3.71
9	0.81	1.53	2.55	2.76	2.77	2.98	3.23	3.75
Avg.	*0.81*	*1.53*	*2.55*	*2.76*	*2.77*	*2.98*	*3.24*	*3.76*

The storm duration used for the study is the 24 hour event. The storm duration selected allows for all portions of the basins to contribute to the basin outlet and is based on the longest time of concentration (Tc) in the model.

Depth – Area Reductions for point rainfall values based upon storm duration and total drainage area size were not considered in the model due to the fact that most basins delineated are less than 5 square miles in area, resulting in minor depth reduction factors. This result, along with the fact that Depth-Area Reductions for 24 hour duration storm events approach unity, was considered in this conclusion. Town officials are in agreement with this methodology.

4. Rainfall Losses

Rainfall losses have been calculated for each basin based upon Land Use and underlying soil characteristics.

Land use data was derived from aerial photography, aerial topographic and planimetric mapping, and Town general planning documentation. Existing land uses have been modeled. Land uses characterized were Low Density Residential, Medium Density Residential, High Density Residential, Very Low Density Residential, Highly Impervious Commercial, Low Impervious Commercial, Agricultural, School, Park, and Vacant.

Detailed soil data was used for this study area. Soil data was derived from use of the "Soil Survey of Yavapai County, Arizona, Western Part" published by the United States Department of Agriculture, Soil Conservation Service and Forest Service in cooperation with Arizona Agricultural Experiment Station issued March of 1976. 46 soil types and their representative loss characteristics were modeled.

Rainfall losses are summarized by 2 components. They are:

1. Other losses (evaporation, interception, surface retention)
2. Infiltration

Other losses are lumped together in the Initial Loss (Ia) modeling parameter. The Ia for each basin was selected using table below as a guide.

Table 3. Initial Losses associated with Land Use

Land Use and/or Land Cover	Surface Retention Loss (inches)
Natural	
Desert and rangeland, flat slope	0.35
Desert and rangeland, hill slope	0.15
Mountain with vegetated surface	0.25
Developed (Residential and Commercial)	
Lawn and turf	0.20
Desert landscape	0.10
Pavement	0.05
Agricultural	
Tilled fields and irrigated pasture	0.50

The predominant Ia value used for residential and vacant land is 0.15 inches for desert and rangeland (hill slope). Other values were used for other land use types. RTIMP is the percent estimated connected impervious area associated with a land use. Percent vegetation is associated with estimated percent vegetation for non impervious areas within a particular land use.

For DTHETA, an antecedent soil moisture condition must be selected (Dry, Normal, or Saturated). The "Dry" condition is defined as non irrigated lands such as desert, rangeland or forest. This condition was selected for all vacant land within the drainage basins. The "Normal" condition was selected for all developed areas.

Table 4. Land Use Data

Land Use	Ia	RTIMP	% Vegetation	Saturation
Very Low Density Residential	0.15	20%	20	normal
Low Density Residential	0.15	30%	40	normal
Medium Density Residential	0.15	40%	50	normal
High Density Residential	0.15	60%	60	normal
School	0.25	45%	70	normal
Commercial – minimal paving	0.10	60%	10	normal
Commercial - impervious	0.05	90%	70	normal
Park	0.20	10%	50	normal
Agricultural	0.50	0%	70	normal
Vacant	0.15	0%	50	dry

Infiltration losses were estimated using the Green and Ampt Infiltration equation. Green and Ampt infiltration losses include 3 parameters. They are:

1. Hydrologic Conductivity (XKSAT)
2. Capillary Suction (PSIF)
3. Soil Moisture Deficit (DTHETA)

These parameters are estimated based on soil texture classification for bare soils. In Arizona, the top 6 inches of soil is generally considered to be adequate to contain infiltrated rain up to the 100 year event. Therefore, when estimating Green and Ampt parameters, the texture of the top 6 inches of soil is considered.

Table 5. General Green and Ampt Equation Loss Rate Parameters

Soil Texture Classification	DTHETA[a] Dry	DTHETA[a] Normal	DTHETA[a] Saturated	XKSAT in/hr	PSIF inches
Sand[b]	.35	.30	0	4.6	1.9
Loamy Sand	.35	.30	0	1.2	2.4
Sandy Loam	.35	.25	0	.40	4.3
Loam	.35	.25	0	.25	3.5
Silt Loam	.40	.25	0	.15	6.6
Silt	.35	.15	0	.10	7.5
Sandy Clay Loam	.25	.15	0	.06	8.6
Clay Loam	.25	.15	0	.04	8.2
Silty Clay Loam	.30	.15	0	.04	10.8
Sandy Clay	.20	.10	0	.02	9.4
Silty Clay	.20	.10	0	.02	11.5
Clay	.15	.05	0	.01	12.4

Table 6. Specific Green and Ampt Soil Loss Parameters

Soil Number	Abbreviation	XKSAT	RTIMP (%)	% Effective
1	Lz	.04	0.0	100.0
2	Wp	.04	0.0	100.0
3	AaB	.25	0.0	100.0
4	LuC	.02	0.0	100.0
5	LmB	.02	0.0	100.0
6	Cx	.40	0.0	100.0
7	Wn	.04	0.0	100.0
8	Ly	.04	0.0	100.0
9	TdC	.02	0.0	100.0
10	LoD	.02	0.0	100.0
11	LmB	.02	0.0	100.0
12	Sa	4.60	0.0	100.0
13	SmB	.01	0.0	100.0
14	LnC	.02	0.0	100.0
15	MgD	.40	0.0	100.0
16	BnD	.40	0.0	100.0
17	MkF	.40	0.0	100.0
18	AyC	.04	0.0	100.0
19	BmF	.40	0.0	100.0
20	BoF	.40	0.0	100.0
21	PmB	.25	0.0	100.0
22	VtE	.04	0.0	100.0
23	PhD	.25	0.0	100.0
24	Ro	.02	0.0	100.0
25	TdE	.02	0.0	100.0
26	AuC	.04	0.0	100.0
27	AlC	.06	0.0	100.0
28	MrC	.40	0.0	100.0
29	LwD	.02	0.0	100.0
30	AnC	.25	0.0	100.0
31	BgD	.04	0.0	100.0
32	BdC	.06	0.0	100.0
33	SlB	.01	0.0	100.0

34	TmD	.20	0.0	100.0
35	TaB	.04	0.0	100.0
36	SnD	.01	0.0	100.0
37	LrD	.02	0.0	100.0
38	LtB	.02	0.0	100.0
39	BlC	.06	0.0	100.0
40	LkD	.02	0.0	100.0
41	GdD	.06	0.0	100.0
42	VtE	.04	0.0	100.0
43	LsC	.02	0.0	100.0
44	JaD	.02	0.0	100.0
45	Po	.06	0.0	100.0
46	LwD	.02	0.0	100.0

The Official Series Descriptions for these soils were obtained from the NRCS web site. They are included in the attached **Appendix** .

Vegetative cover over impervious areas was considered when using the Green and Ampt Equation for infiltration losses. The parameters listed in **Table 6** are for bare soil. The XKSAT parameter was adjusted for vegetative cover in each sub basin.

Figure 2. Vegetative Cover Correction for XKSAT

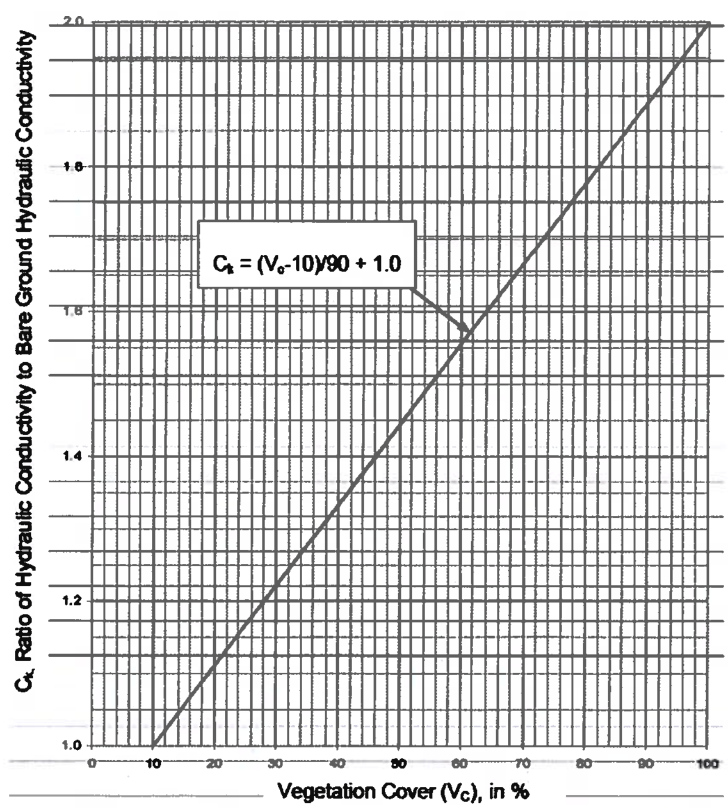


Table 7. Rainfall Loss Parameters

Basin	Ia	DTHETA	PSIF	XKSAT	RTIMP
100	0.15	0.335	6.857	.151	2.273
200	0.138	0.293	7.204	0.125	13.846
201	0.15	0.245	8.151	0.092	9.706
202	0.13	0.231	6.720	0.162	32.857
203	0.149	0.276	8.088	0.095	4.649
204	0.168	0.166	8.409	0.086	34.521
205	0.15	0.113	11.200	0.029	34.286
206	0.148	0.179	10.024	0.044	17.368
207	0.15	0.190	11.200	0.029	0.000
208	0.15	0.133	10.030	0.046	40.000
209	0.15	0.150	9.700	0.058	40.000
210	0.15	0.181	10.602	0.037	11.429
211	0.15	0.190	10.806	0.034	4.750
212	0.159	0.139	10.087	0.042	33.811
213	0.139	0.172	9.700	0.052	32.222
214	0.147	0.155	9.970	0.043	24.667
215	0.133	0.100	11.200	0.026	46.667
216	0.182	0.099	10.969	0.026	21.667
217	0.145	0.136	10.750	0.033	29.024
218	0.15	0.231	9.955	0.049	0.000
219	0.151	0.184	10.344	0.038	8.190
220	0.15	0.120	11.200	0.024	15.556
221	0.15	0.187	9.064	0.056	16.071
222	0.15	0.179	11.200	0.028	2.500
223	0.15	0.239	7.230	0.110	15.604
224	0.13	0.154	11.200	0.025	24.000
225	0.15	0.250	5.080	0.228	22.222
226	0.15	0.190	11.200	0.029	0.000
227	0.15	0.207	7.572	0.093	13.333
228	0.15	0.199	7.870	0.091	20.571
229	0.15	0.101	11.163	0.028	37.619
230	0.15	0.190	11.200	0.029	0.000
231	0.148	0.192	11.040	0.031	2.000
232	0.129	0.159	11.092	0.027	23.793
233	0.15	0.174	11.200	0.028	3.636
234	0.15	0.176	11.200	0.028	3.077
235	0.15	0.19	11.200	0.029	0.000
236	0.149	0.195	11.001	0.032	0.865
237	0.15	0.198	10.905	0.033	0.000
Avg.(200's)	**0.157**	**0.191**	**10.465**	**0.058**	**17.792**

Basin	**Ia**	**DTHETA**	**PSIF**	**XKSAT**	**RTIMP**
300	0.152	0.277	7.066	0.133	9.270
301	0.162	0.237	7.553	0.107	13.330
302	0.130	0.250	7.000	0.127	28.000
303	0.150	0.250	9.700	0.058	0.000
304	0.185	0.177	9.462	0.058	15.560
305	0.145	0.290	7.000	0.140	14.000
306	0.148	0.171	8.099	0.096	35.240
307	0.150	0.250	9.700	0.058	0.000
308	0.250	0.150	9.700	0.067	45.000
309	0.150	0.119	10.650	0.032	28.280
310	0.164	0.188	8.552	0.072	19.420
Avg.(300's)	**0.149**	**0.189**	**7.947**	**0.074**	**18.075**
400	0.136	0.236	7.000	0.122	22.860
401	0.133	0.294	5.900	0.196	32.610
Avg.(400's)	**0.135**	**0.265**	**6.450**	**0.159**	**27.735**
500	0.195	0.289	5.479	0.258	7.419
501	0.150	0.332	6.432	0.178	7.273
Avg.(500's)	**0.173**	**0.311**	**5.956**	**0.218**	**7.346**
600	0.220	0.224	5.261	0.282	16.667
601	0.148	0.295	4.984	0.310	17.500
602	0.150	0.298	5.838	0.228	26.364
603	0.150	0.350	4.800	0.361	0.000
604	0.150	0.364	6.720	0.165	0.000
605	0.150	0.370	5.219	0.301	0.000
606	0.150	0.150	9.700	0.058	40.000
607	0.145	0.165	7.684	0.109	38.182
608	0.148	0.207	9.955	0.047	8.437
609	0.150	0.229	9.780	0.054	4.074
610	0.150	0.250	5.667	0.239	36.000
611	0.150	0.156	8.179	0.095	38.462
Avg.(600's)	**0.155**	**0.255**	**6.982**	**0.187**	**18.807**
700	0.150	0.250	5.508	0.240	29.730
701	0.150	0.100	11.200	0.027	30.000
702	0.150	0.161	8.579	0.075	28.298
703	0.150	0.350	4.800	0.361	0.000
704	0.150	0.170	10.971	0.031	8.824
Avg.(700's)	**0.150**	**0.206**	**8.212**	**0.147**	**19.370**

800	0.150	0.250	3.950	0.400	30.000
900	0.150	0.216	6.341	0.177	30.000
1000	0.150	0.211	8.419	0.074	13.055
Avg. (All)	**0.152**	**0.209**	**8.736**	**0.102**	**17.792**

5. Unit Hydrographs

In the absence of a data base to develop unit hydrographs for the sub areas, synthetic unit hydrographs are used in the modeling. The recommended synthetic unit hydrograph procedure for Arizona is the Clark Unit Hydrograph.

The Clark Unit Hydrograph requires the estimation of 3 parameters; Time of Concentration (Tc), Storage Coefficient (R), and Time-Area Relation. The Tc is also used to select the storm duration and computation interval (NMIN).

The Tc is the travel time for a floodwave to travel from the most hydraulically distant point in the watershed to the point of interest or concentration point. The equation for Desert/Mountain areas is:

$$Tc = 2.4\ A^{0.1}\ L^{0.25}\ L_{ca}^{0.25}\ S^{-0.2}$$

Tc	=	time of concentration (hrs)
A	=	area (sm)
L	=	length of watercourse to the hydraulically most distant point (mi)
L_{ca}	=	length measured from the concentration point along L to a point that is perpendicular to the sub basin centroid (mi)
S	=	watercourse slope (ft/mi)

The R (in hours) parameter relates the effects of direct runoff storage in the sub basin to the unit hydrograph shape. The equation is:

$$R = 0.37\ Tc^{1.11}\ L^{0.8}\ A^{-0.57}$$

The Time-Area Relation is a graphical parameter that specifies the accumulated area of the sub basin that is contributing runoff to the outlet or concentration point of sub basin at any time. Synthetic Time-Area Relations are typically used in Arizona. Curve B was used for this study.

Table 8. Time-Area Relation

Travel Time, as a percent of T_c (1)	Contributing Area, as a Percent of Total Area[a] A (2)	B^b (3)	C (4)
0	0	0.0	0
10	5	4.5	3
20	16	12.6	5
30	30	23.2	8
40	65	35.8	12
50	77	50.0	20
60	84	64.2	43
70	90	76.8	75
80	94	87.4	90
90	97	95.5	96
100	100	100.0	100

[a] – The dimensionless Synthetic Time-Area relations should be selected as follows:

A – The land-use in the watershed or subbasin is urban or predominantly urban.

B – All watersheds or subbasins other than those defined for use of curves A or C.

C – The land-use in the watershed or subbasin is desert/rangeland or is mostly desert/rangeland with some mountains in the watershed and/or some irrigated agricultural fields interspersed in the lowlands.

[b] – Curve B is the HEC-1 default Time-Area relation and the UA record is not needed as input to the HEC-1 model.

The duration of the unit hydrographs is specified in the NMIN parameter. NMIN is typically 5 minutes for a 24 hour duration storm. Generally, NMIN should not exceed 0.25 Tc for the shortest Tc in the model. A NMIN of 5 minutes is generally adequate.

The Tc and R parameters for the Clark Unit hydrograph procedure were developed for larger, less frequent storm events. For return periods less than the 25 year event, the use of these equations will typically result in estimates that are too short. Per the *State Standard*, the Tc should be increased as much as 100% for more frequent events such as the 2 year event. R must also be recalculated because it is dependent on Tc. For this study, Tc was increased by 75% for the 2 year event and 25% for the 10 year event.

Table 9. 25, 50 and 100 Year Event Unit Hydrograph Parameters

Basin	Tc (hr)	R (hr)	Time-Area Curve
100	1.584	0.889	B
200	0.610	0.547	B
201	1.237	1.014	B
202	1.020	1.017	B
203	1.574	0.737	B
204	1.166	0.801	B
205	0.547	0.64	B
206	0.932	0.531	B
207	0.431	0.323	B
208	0.372	0.246	B
209	0.324	0.449	B
210	0.843	0.662	B
211	1.624	1.286	B
212	1.281	0.789	B
213	0.538	0.476	B
214	0.791	0.822	B
215	0.343	0.349	B
216	0.917	0.942	B
217	0.827	0.67	B
218	0.302	0.231	B
219	2.914	2.445	B
220	0.625	0.60	B
221	0.775	0.653	B
222	0.530	0.497	B
223	1.102	0.679	B
224	0.359	0.26	B
225	0.614	0.625	B
226	0.672	0.468	B
227	0.676	0.699	B
228	0.970	0.923	B
229	0.942	0.795	B
230	1.474	0.934	B
231	1.375	1.100	B

Basin	Tc (hr)	R (hr)	Time-Area Curve
232	0.782	0.588	B
233	0.777	0.766	B
234	0.648	0.705	B
235	0.306	0.228	B
236	1.246	0.943	B
237	1.634	1.217	B
300	1.351	1.286	B
301	0.883	0.688	B
302	0.708	0.717	B
303	0.672	0.559	B
304	0.904	0.662	B
305	0.647	0.689	B
306	0.810	0.641	B
307	0.334	0.290	B
308	0.503	0.452	B
309	1.399	1.055	B
310	1.360	1.676	B
400	0.592	0.570	B
401	1.003	1.338	B
500	0.788	0.593	B
501	0.595	0.527	B
600	0.955	0.771	B
601	0.860	0.804	B
602	0.898	0.627	B
603	0.232	0.229	B
604	0.450	0.425	B
605	0.539	0.437	B
606	0.413	0.431	B
607	0.916	1.045	B
608	0.989	0.988	B
609	0.908	0.891	B
610	0.556	0.367	B
611	0.791	0.655	B
700	0.933	0.760	B
701	0.320	0.283	B
702	0.980	0.819	B
703	0.336	0.262	B
704	1.085	1.002	B
800	0.307	0.273	B
900	0.620	0.582	B
1000	4.371	1.960	B

Table 10. 10 Year Event Unit Hydrograph Parameters

Basin	Tc (hr)	R (hr)	Time-Area Curve
100	1.980	1.139	B
200	0.760	0.700	B
201	1.550	1.300	B
202	1.280	1.302	B
203	1.940	0.943	B
204	1.450	1.035	B
205	0.680	0.819	B
206	1.170	0.679	B
207	0.540	0.414	B
208	0.360	0.280	B
209	0.410	0.573	B
210	1.050	0.849	B
211	2.030	1.647	B
212	1.600	1.011	B
213	0.670	0.608	B
214	0.990	1.054	B
215	0.430	0.450	B
216	1.150	1.208	B
217	1.030	0.859	B
218	0.380	0.295	B
219	3.640	3.132	B
220	0.780	0.770	B
221	0.940	0.837	B
222	0.660	0.639	B
223	1.380	0.870	B
224	0.450	0.333	B
225	0.770	0.800	B
226	0.840	0.600	B
227	0.850	0.895	B
228	1.210	1.182	B
229	1.180	1.019	B
230	1.840	1.197	B
231	1.720	1.410	B

Basin	Tc (hr)	R (hr)	Time-Area Curve
232	0.980	0.752	B
233	0.970	0.982	B
234	0.810	0.904	B
235	0.380	0.292	B
236	1.560	1.207	B
237	2.040	1.558	B
300	1.690	1.648	B
301	1.100	0.880	B
302	0.890	0.920	B
303	0.840	0.717	B
304	1.130	0.847	B
305	0.800	0.865	B
306	1.000	0.822	B
307	0.450	0.378	B
308	0.620	0.572	B
309	1.760	1.362	B
310	1.700	2.146	B
400	0.750	0.737	B
401	1.260	1.721	B
500	0.990	0.759	B
501	0.740	0.674	B
600	1.190	0.987	B
601	1.080	1.029	B
602	1.120	0.803	B
603	0.290	0.297	B
604	0.560	0.544	B
605	0.670	0.560	B
606	0.520	0.550	B
607	1.150	1.338	B
608	1.240	1.265	B
609	1.140	1.142	B
610	0.700	0.471	B
611	0.990	0.833	B
700	1.170	0.974	B
701	0.400	0.365	B
702	1.230	1.050	B
703	0.420	0.335	B
704	1.360	1.284	B
800	0.380	0.353	B
900	0.780	0.744	B
1000	5.460	2.510	B

Table 11. 2 Year Event Unit Hydrograph Parameters

Basin	Tc (hr)	R (hr)	Time-Area Curve
100	2.770	1.654	B
200	1.070	1.017	B
201	2.160	1.888	B
202	1.790	1.892	B
203	2.750	1.370	B
204	2.040	1.491	B
205	0.960	1.190	B
206	1.670	1.057	B
207	0.750	0.601	B
208	0.650	0.458	B
209	0.570	0.833	B
210	1.480	1.233	B
211	2.840	2.393	B
212	2.240	1.441	B
213	0.940	0.884	B
214	1.380	1.532	B
215	0.600	0.654	B
216	1.600	1.755	B
217	1.450	1.248	B
218	0.530	0.429	B
219	5.100	4.551	B
220	1.090	1.119	B
221	1.360	1.216	B
222	0.930	0.928	B
223	1.930	1.264	B
224	0.630	0.484	B
225	1.070	1.162	B
226	1.180	0.872	B
227	1.180	1.300	B
228	1.700	1.717	B
229	1.650	1.481	B
230	2.580	1.739	B
231	2.410	2.048	B

Basin	Tc (hr)	R (hr)	Time-Area Curve
232	1.370	1.092	B
233	1.360	1.426	B
234	1.130	1.313	B
235	0.540	0.424	B
236	2.180	1.754	B
237	2.860	2.264	B
300	2.360	2.394	B
301	1.550	1.281	B
302	1.240	1.337	B
303	1.180	1.041	B
304	1.580	1.231	B
305	1.130	1.285	B
306	1.390	1.191	B
307	0.630	0.549	B
308	0.880	0.840	B
309	2.450	1.963	B
310	2.380	3.118	B
400	1.040	1.061	B
401	1.760	2.489	B
500	1.380	1.103	B
501	1.040	0.979	B
600	1.670	1.434	B
601	1.510	1.495	B
602	1.570	1.167	B
603	0.410	0.431	B
604	0.790	0.791	B
605	0.940	0.814	B
606	.720	0.799	B
607	1.600	1.944	B
608	1.730	1.838	B
609	1.590	1.659	B
610	0.970	0.684	B
611	1.390	1.219	B
700	1.630	1.415	B
701	0.560	0.531	B
702	1.720	1.526	B
703	0.590	0.486	B
704	1.900	1.866	B
800	0.540	0.512	B
900	1.090	1.081	B
1000	7.650	3.647	B

6. Channel and Storage Routing

Chino Valley has a number of old Irrigation District ditches which used to divert low flows to agricultural fields. These irrigation ditches have generally been abandoned and are no longer maintained. The ditches have limited capacities and were not considered as diversion structures for this model. There are also numerous small earthen berms throughout the study area that are not considered to have a significant impact on storage routing, and were not included in the model.

Channel routing was considered for basins in series in accordance with the Modified Puls normal depth channel routing procedures. 12 typical sections for routing channel characteristics were modeled. These channels were defined as being generally characteristic for transporting upstream flows. Channel routing will cause hydrograph transference and attenuation. Results are shown in the **Appendix**.

7. Hydrologic Modeling Results

The results of the peak discharges derived from the model are provided below.

Table 12. Hydrologic Modeling Results – Basin Peak Discharges

Basin	2 yr	10 yr	25 yr	50 yr	100 yr
100	170	627	1119	1385	1677
200	27	77	127	153	182
201	76	220	370	445	528
202	51	134	217	263	311
203	391	1221	2086	2532	3015
204	128	322	516	611	715
205	25	57	85	100	116
206	257	682	1041	1223	1475
207	57	137	209	245	286
208	45	112	147	174	202
209	8	17	26	31	36
210	111	285	450	531	620
211	188	501	820	967	1134
212	236	567	892	1050	1224
213	32	77	117	139	161
214	36	87	138	162	189
215	14	30	46	53	61
216	63	150	233	273	317
217	111	263	407	478	558

Basin	2 yr	10 yr	25 yr	50 yr	100 yr
218	19	46	69	83	97
219	329	878	1439	1708	2075
220	35	81	124	145	169
221	59	152	242	286	335
222	28	68	106	125	146
223	141	399	661	801	942
224	27	67	99	116	134
225	16	56	92	112	134
226	118	300	466	548	640
227	33	90	146	174	205
228	55	147	240	286	337
229	94	218	337	394	458
230	268	715	1158	1370	1605
231	181	481	779	924	1083
232	79	193	295	348	404
233	48	121	190	225	262
234	31	78	122	144	168
235	20	45	67	79	92
236	153	408	660	782	915
237	202	546	893	1055	1282
300	67	203	350	427	511
301	58	165	275	331	391
302	24	64	105	125	147
303	31	86	139	167	197
304	80	208	332	395	463
305	16	48	79	96	113
306	57	141	224	265	323
307	16	42	63	79	95
308	24	57	85	101	118
309	196	466	738	868	1039
310	53	140	229	272	319
400	33	78	145	173	203
401	26	68	112	136	162
500	37	124	219	272	331
501	19	61	104	128	154
600	53	161	276	339	409
601	30	91	157	194	239
602	66	186	311	379	453
603	3	12	21	26	31
604	12	42	71	88	106
605	13	50	91	115	141
606	26	60	90	106	124

Basin	2 yr	10 yr	25 yr	50 yr	100 yr
607	36	91	145	173	204
608	53	142	231	275	324
609	41	115	188	224	264
610	36	94	153	183	217
611	61	151	236	280	324
700	59	161	268	325	387
701	17	37	56	64	75
702	80	201	322	381	446
703	9	38	66	83	101
704	83	206	335	396	463
800	11	29	48	57	68
900	31	83	133	160	189
1000	1462	4084	6764	8143	9652

Table 13. Hydrologic Modeling Results – Concentration Point Peak Discharges

Concentration Point	Cont. Area (s.m.)	2 yr (cfs)	10 yr (cfs)	25 yr (cfs)	50 yr (cfs)	100 yr (cfs)
100	2.49	170	627	1119	1385	1677
200	26.79	2858	7351	11454	13561	15597
201	26.65	2856	7370	11494	13617	15609
202	0.37	51	134	217	263	311
203	3.77	391	1221	2086	2532	3015
204	0.75	128	322	516	611	715
205	0.08	25	57	85	100	116
206	21.84	2377	5958	9288	10980	12441
207	0.14	57	137	209	245	286
208	14.10	1903	4872	7601	9021	10603
209	0.02	8	17	26	31	36
210	0.51	111	285	450	531	620
211	1.71	188	503	820	972	1140
212	11.78	1650	4210	6534	7749	9111
213	0.10	32	77	117	139	161
214	5.54	334	887	1448	1719	2088
215	0.03	14	30	46	53	61
216	0.70	149	366	568	683	786
217	9.81	1270	3330	5269	6260	7393
218	0.04	19	46	69	83	97

Concentration Point	Cont. Area (s.m.)	2 yr (cfs)	10 yr (cfs)	25 yr (cfs)	50 yr (cfs)	100 yr (cfs)
219	5.37	329	878	1439	1708	2075
220	0.39	87	218	338	401	469
221	0.27	59	152	242	286	335
222	0.09	28	68	106	125	146
223	9.27	1177	3127	4994	5934	7019
224	0.06	27	67	99	116	134
225	4.40	550	1423	2249	2670	3160
226	2.34	307	822	1338	1585	1861
227	1.54	197	527	855	1014	1189
228	3.52	421	1112	1799	2130	2538
229	0.77	167	398	608	718	843
230	1.92	268	715	1158	1370	1605
231	1.37	181	481	779	924	1083
232	3.16	385	1032	1681	1987	2369
233	0.23	48	121	190	225	262
234	0.13	31	78	122	144	168
235	0.04	20	45	67	79	92
236	1.03	153	408	660	782	915
237	1.79	202	546	893	1055	1282
300	4.05	456	1125	1851	2120	2629
301	2.57	302	704	1146	1304	1628
302	0.68	126	336	533	641	757
303	0.15	31	86	139	167	197
304	0.40	80	208	332	395	463
305	2.21	280	658	1063	1219	1510
306	2.11	275	647	1042	1199	1478
307	1.32	202	475	750	882	1057
308	1.28	201	474	747	879	1053
309	1.21	196	466	738	868	1039
310	0.54	53	140	229	272	319
400	0.38	49	130	217	260	305
401	0.23	26	68	112	136	162
500	0.44	49	161	275	349	433
501	0.12	19	61	104	128	154
600	2.67	346	944	1525	1879	2273
601	0.78	93	263	436	545	665
602	0.52	68	192	321	394	476
603	0.01	3	12	21	26	31
604	0.07	12	42	71	88	106
605	0.18	37	105	170	208	251

Concentration Point	Cont. Area (s.m.)	2 yr (cfs)	10 yr (cfs)	25 yr (cfs)	50 yr (cfs)	100 yr (cfs)
606	0.07	26	60	90	106	124
607	0.86	124	324	530	636	753
608	0.63	94	256	418	498	586
609	0.27	41	115	188	224	264
610	0.39	84	211	330	396	464
611	0.26	61	151	236	280	324
700	1.43	207	536	863	1028	1215
701	0.03	17	37	56	64	75
702	1.00	159	404	647	766	906
703	0.05	9	38	66	83	101
704	0.51	83	210	335	396	463
800	0.03	11	29	48	57	68
900	0.14	31	83	133	160	189
1000	31.54	1462	4084	6764	8143	9652

8. *Indirect Methods of Discharge Verification*

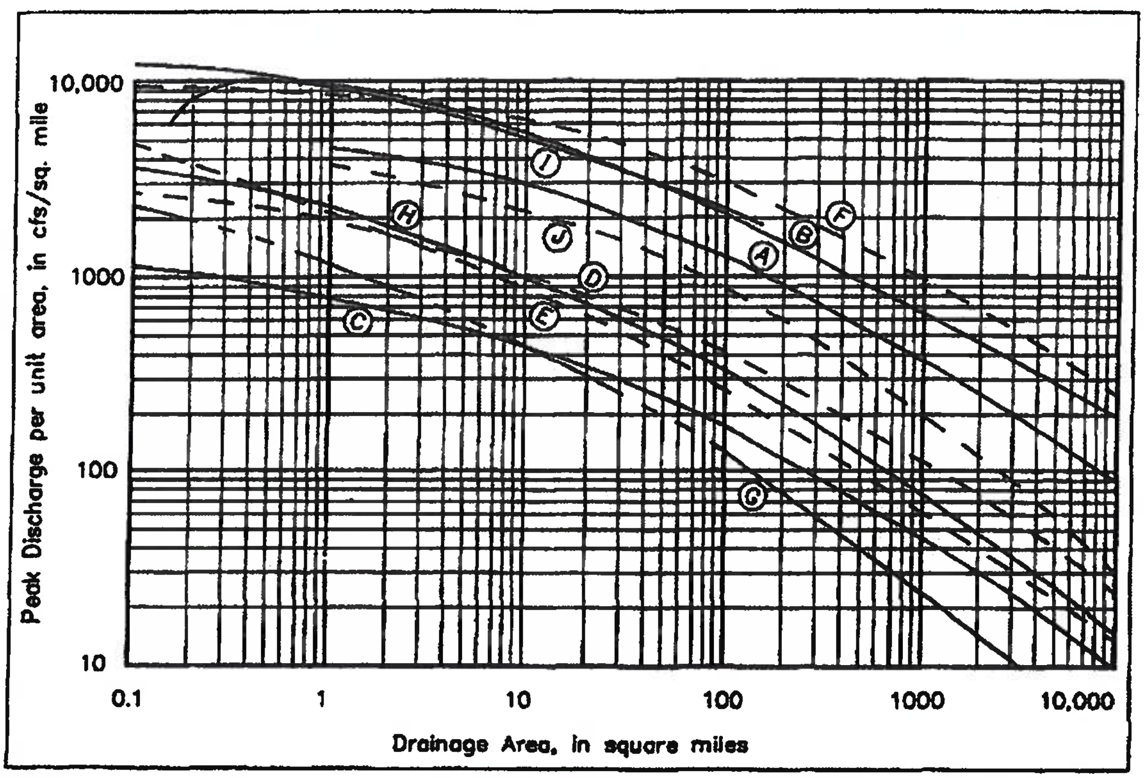
The estimation of peak discharges by analytic methods is based on various assumptions and estimated parameters. For ungaged watersheds, peak discharge estimates should be checked for validity using indirect methods. The *Highway Drainage Design Manual Hydrology* by the Arizona Department of Transportation (ADOT) provides various indirect methods for peak discharge verification. Four representative basins have been selected for testing indirect methods vs. HEC-1 calculated peak discharge results.

Indirect Method Number 1 – Unit Peak Discharge Curves

The curves of most interest are Curve C, Curve G, and Curve H. Curve H is a 100 year event peak discharge *envelope* for Southeastern Arizona. Curve C and G are 100 year event peak discharge relations developed for Arizona. Curve G is a 100 year event peak discharge relation for Southeastern Arizona. Curve C is for Arizona.

Curves A, B, D, E, F, I, and J were developed from maximum observed flood discharges.

Figure 3. Peak Discharge Relations and Envelope Curves



Indirect Method Number 2 – USGS Data for Arizona

The United States Geological Survey (USGS) collects streamflow data and provides statistical analysis for 138 continuous record streamflow gaging stations and 176 partial record gaging stations in Arizona. The data is analyzed using a Log-Pearson Type 3 analysis. Based on the analysis, an equation was developed for the 100 year event peak discharge:

$$Q_{100} = 850\ A^{0.54}$$

Q_{100}	=	100 year event peak discharge
A	=	Drainage area (sm)

Indirect Method Number 3 – Regional Regression Equations

An analysis was performed of streamflow data in Arizona, Nevada, Utah, and parts of New Mexico, Colorado, Wyoming, Texas, Idaho, Oregon, and California. The analysis resulted in 16 sets of regional regression equations for the study area. Arizona has 7 regions. The study area lies in Region 12.

The equation for the 100 year event in Region 12 is:

$$\text{Log } Q = 6.55 - 3.17\ \text{Area}^{-0.11} - 0.454\ \text{Log Elev}$$

Area	=	Drainage area (sm)
Elev	=	Mean basin elevation divided by 1,000

4,900 ft for Basin 1000
4,650 ft for Basin 100
4,700 ft for Basin 219
4,800 ft for Basin 211

Figure 4. Regional Regression Map

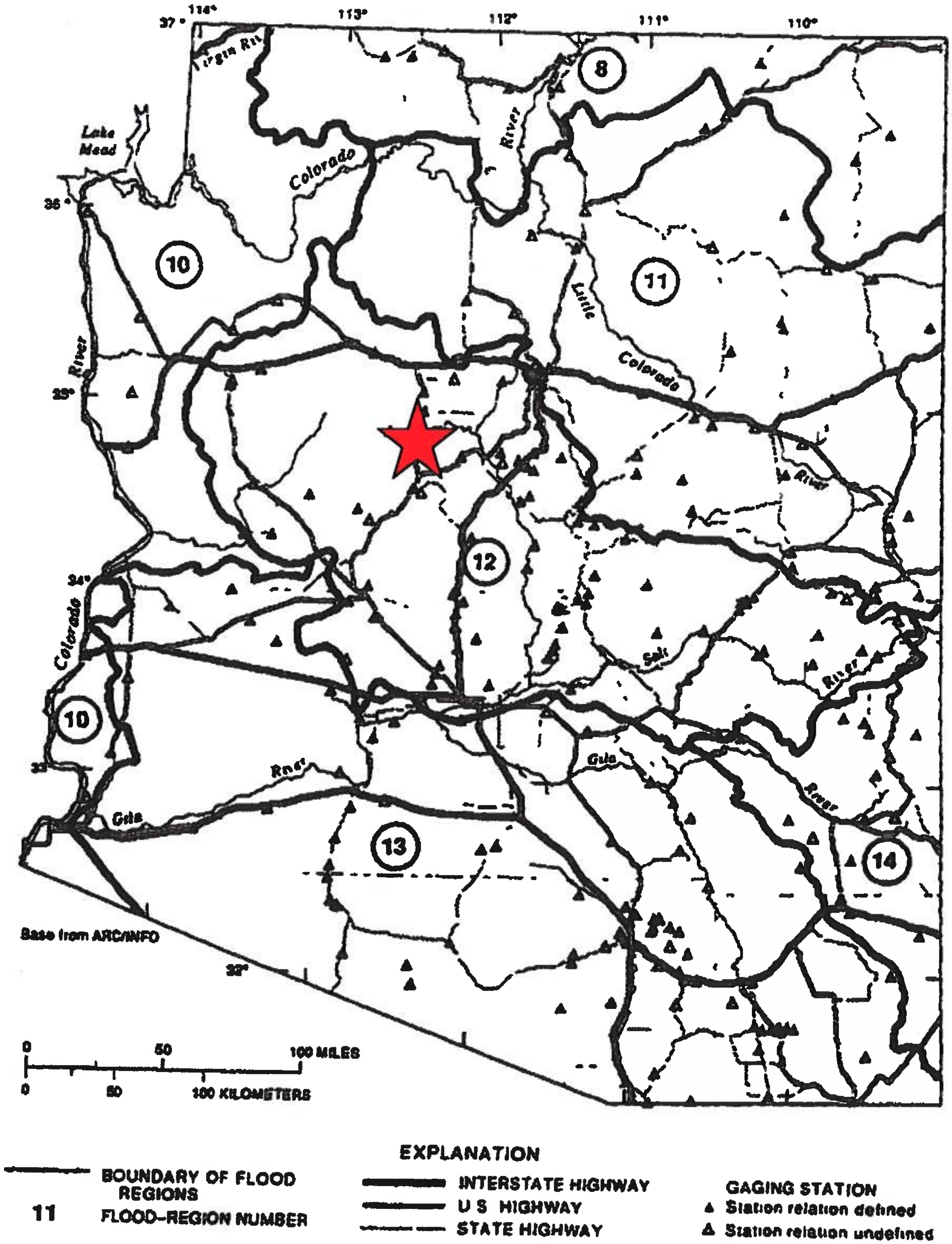


Table 14. Indirect Discharge Verification Results (100 yr.)

Discharge Method	Basin 100	Basin 211	Basin 219	Basin 1000
No. 1 Curve C	1,590 cfs	1,000 cfs	2,850 cfs	9,460 cfs
No. 1 Curve G	2,040 cfs	1,670 cfs	3,200 cfs	6,930 cfs
No. 1 Curve H	2,690 cfs	1,840 cfs	5,530 cfs	18,900 cfs
No. 2	1,390 cfs	1,120 cfs	2,107 cfs	5,480 cfs
No. 3 (region 12)	2,400 cfs	1,756 cfs	3,975 cfs	11,695 cfs
HEC-1 Study	1,677 cfs	1,134 cfs	2,075 cfs	9,652 cfs

III. Area Drainage Master Study Conclusion

HEC-1 was used to analyze the drainage basins impacting the various drainage basin locations in the Town of Chino Valley. The 2, 10, 25, 50, and 100 year 24 hour events were analyzed. The analysis also includes channel routing analyses for combined basins.

The modeling results were compared to various indirect methods of discharge verification. In general, the modeling results appear to be comparatively close to method number one, curve C, which is a direct 100 year discharge relationship for Arizona in general. Other methods yield varying results.

IV. Recharge Potential

1. General Discussion

Natural recharge is defined as source areas and pathways for precipitation to reach the regional groundwater aquifers. Artificial recharge areas are those that would facilitate the construction of recharge facilities to promote the movement of water from the surface of the ground to the regional aquifers. This report addresses preliminary feasibility of artificial recharge in the Chino Valley area. The focus will be to narrow the search to areas that are more likely to have potential positive recharge characteristics than not.

The soils and geologic conditions in Chino Valley vary considerably. Some areas in Chino Valley consist of hundreds of feet of thickness of heavy clay soils or thick basement rock units that do not render positive recharge potentials. Other areas seem to show encouraging characteristics. Recharge sites in Chino Valley should ultimately be decided upon after detailed soils and geologic testing measures have been taken. Local soil and hydrogeologic conditions will affect the amount of recharge that occurs.

Issues that are relevant to artificial recharge activities are soil permeability, geologic characteristics, hydrogeologic characteristics, depth to static ground water, appropriation concerns, legal issues, types of recharge facilities such as basins, injection wells, harvesting and transportation of recharge water, and costs versus benefits. Water quality and soil and aquifer treatment processes are also considerations with artificial recharge.

2. Subsurface Mapping

Recent geologic mapping from the USGS is included herein for the purpose of generally describing areas in Chino Valley that are more suited for recharge potential than others. This soil survey data generally provides information for the predominant geological feature of the subsurface. Deeper lithological strata will affect the ability of water to be recharged into the regional aquifer. Based on the upper subsurface soil characteristics, areas shown as Qal (Alluvium) are more attractive than other areas such as Tlal (Lower Unit) shown on the maps.

Recent recharge potential mapping was also performed by Southwest Groundwater Inc. for the Upper Verde River Watershed Protection Coalition which shows areas more prone to successful recharge than others in the Verde River watershed. This map is also included herein. The Southwest mapping focused on areas of potentially favorable artificial recharge based on soil permeability and depth to existing groundwater.

In 2008, the Town of Chino Valley commissioned a Preliminary Assessment of a Recharge Feasibility for a sand and gravel site near Paulden by Errol L. Montgomery & Associates. This report shows an area in the vicinity of north Chino Valley that may have potential for artificial recharge.

Figure 5. USGS Subsurface Map

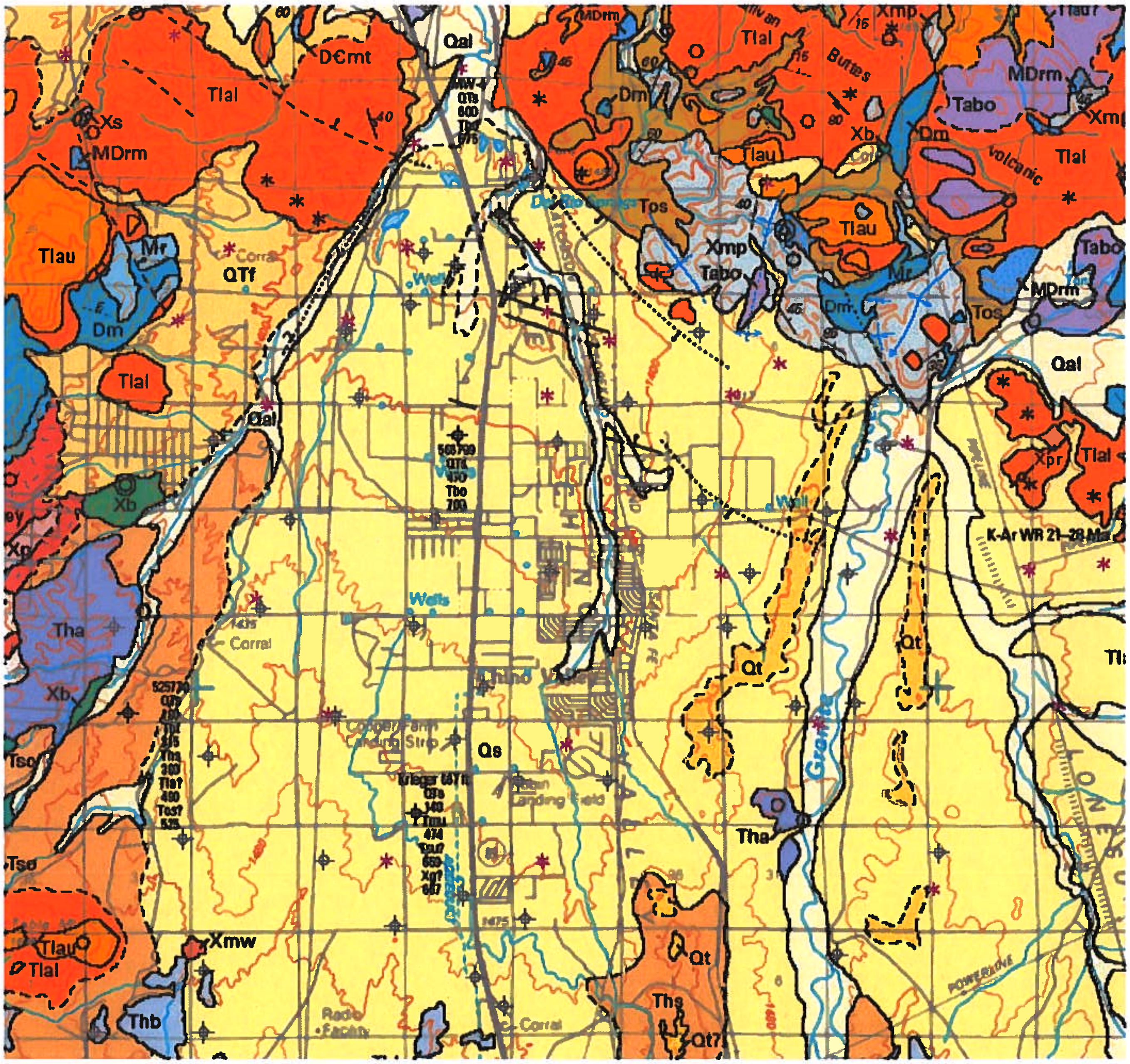
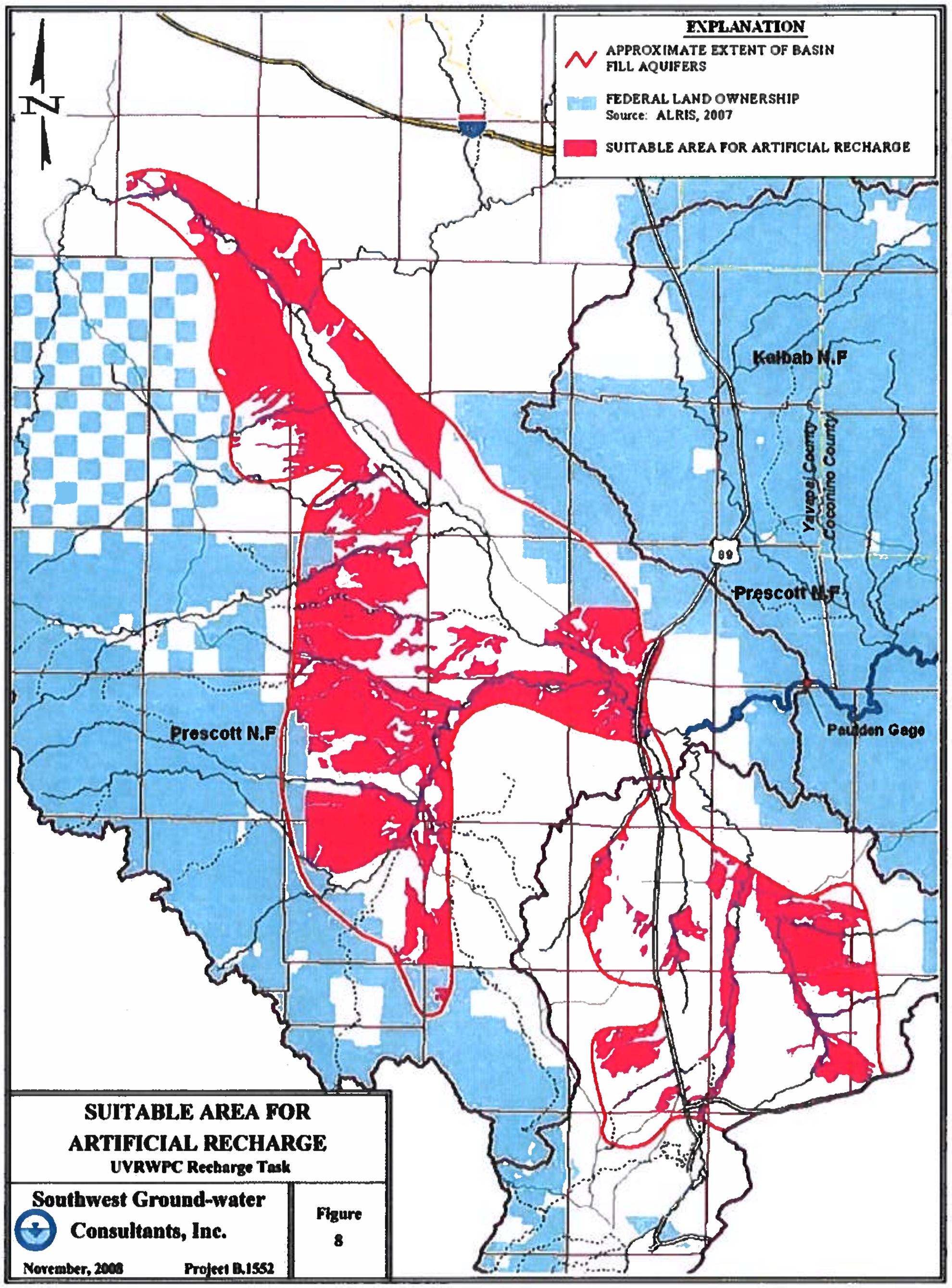


Figure 6. Southwest Groundwater Map

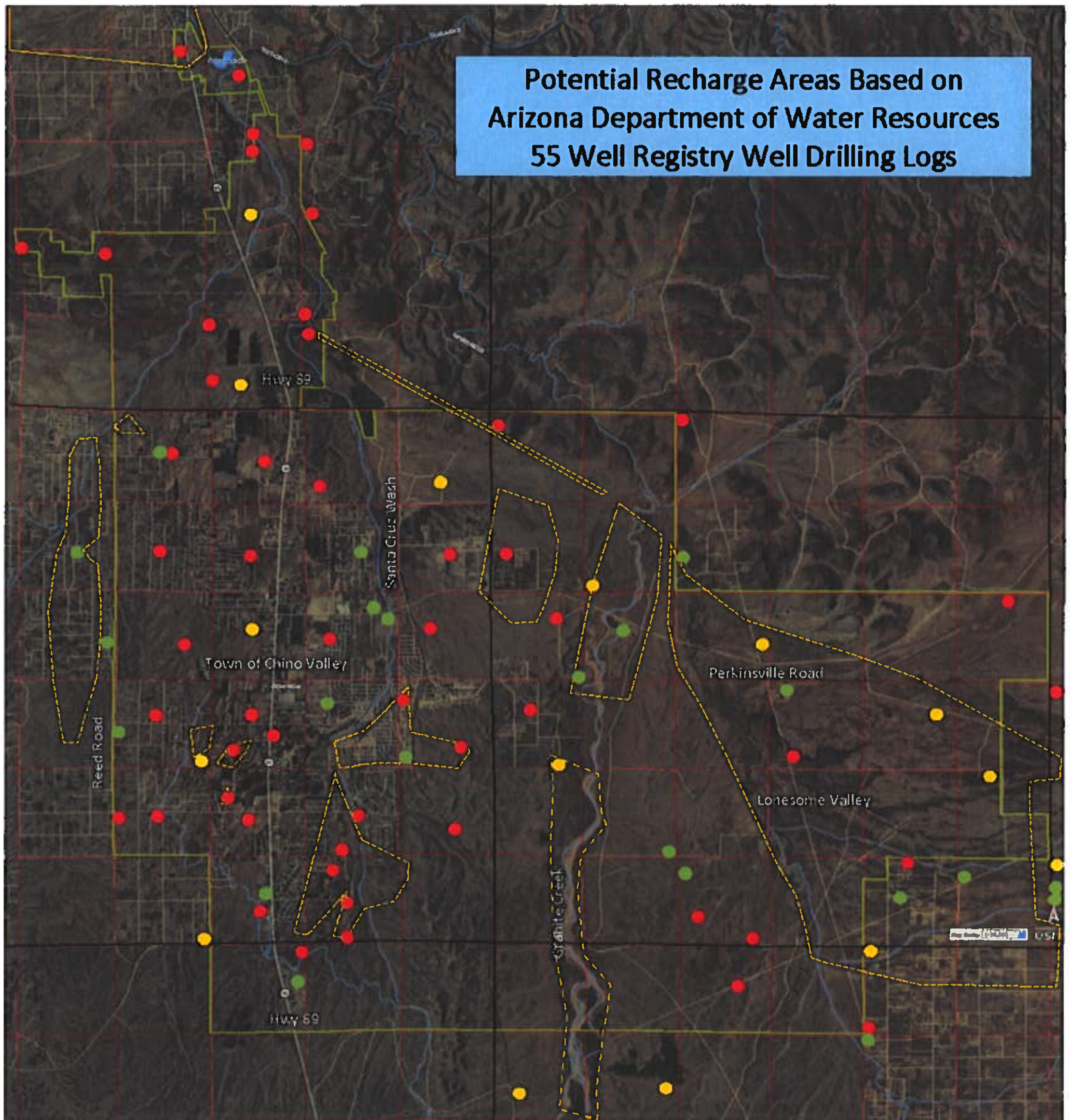


3. Well Logs

A cursory study of a representative number of well logs was performed for the purpose of developing a general understanding of areas that may be more suitable for recharge geologic characteristics than others. A general map of these areas is also included herein.

In general, areas of possible recharge potential based upon mapping data and well log data are shown in west Chino Valley, in the vicinity of Reed Road between Road 2 South and Road 5 North, north Chino Valley in the area of the confluence of the Williamson Valley Wash and the Big Chino wash (depending on proximity of ground water), Granite Creek, some locations along the Santa Cruz Wash, and possible mountain front recharge enhancements near the outlets of Martin and CCC Canyons. See the attached referenced maps. Final planning for recharge efforts should be based upon more detailed subsurface soil and geologic explorations. See Figure 7 for potential recharge areas based upon well log research.

Figure 7. Potential Recharge Areas Based on Well Logs



- (green dot) Well Log shows good potential for recharge within 150 feet from surface. Presence of coarse grain material and relatively low groundwater table.
- (yellow dot) Well Log shows possible potential for recharge within 150 feet from surface. Well log not clear or complete. Needs more investigation.
- (red dot) Well Log shows poor potential for recharge within 150 feet from surface. Presence of fine grain material or relatively high groundwater table.
- (green line) Town of Chino Valley jurisdictional limits.
- (yellow dashed line) Approximate duplicated limits of suitable areas for artificial recharge identified by Southwest Ground-water Consultants Inc. in report entitled "Report Task No. 5, Recharge Mapping", November 2008 for the Upper Verde River Watershed Protection Coalition.

Background map from Yavapai County GIS, Scale = 1 : 36,000

4. Credits

The Arizona Department of Water Resources (ADWR) currently recognizes three types of water that qualify for either long term or short term recharge credits. They are treated sewage effluent, Central Arizona Project (CAP) water from the Colorado River, and appropriated surface water. Based on discussions with ADWR staff, there is no current mechanism in statute that describes methods for obtaining recharge credits for unappropriated surface waters.

In Arizona, the amount of water available under a surface water right is subject to prior right appropriations. The doctrine of "prior appropriation" applies to surface water, which basically means first in time is first in right.

Appropriated surface water is defined by A.R.S. 45-101(9) as waters of all sources, flowing in streams, canyons, ravines or their natural channels, or in definite underground channels, whether perennial or intermittent, floodwater, wastewater or surplus water, and of lakes, ponds and springs on the surface. Surface waters must be put to beneficial use in order to qualify for appropriation. Beneficial uses are limited to domestic, municipal, irrigation, stock watering, power, recreation, wildlife including fish, non-recoverable water storage and mining uses (A.R.S. 45-151(A)).

5. Facilities

Artificial recharge can be accomplished by surface infiltration or injection into the vadose zone or saturated zones using wells. Injection wells that are used to recharge waters of poor quality are subject to higher treatment requirements than those that inject waters to the vadose zone. Surface infiltration mechanisms are typically spacial or linear pond configurations. Surface basins require more land area than injection well applications. Mountain front recharge enhancements with berms, basins and dams which direct flows to shallow basalt could be considered.

V. References

ADOT Highway Drainage design Manual Hydrology – March 1993

US Army Corps of Engineers Hydrologic Engineering Center HEC-1 Flood Hydrograph Package User's Manual – June 1998

Cooper Aerial 2 Foot Aerial Mapping, May 2010

ADWR State Standard for Hydrologic Modeling, 2007

USGA National Map Data Seamless Server

NOAA Precipitation Data Server

NRCS Detailed Western Yavapai County Soil Survey

Errol L. Montgomery & Associates Inc. – Report – Preliminary Assessment of Recharge Feasibility for Site near Paulden, Yavapai County Arizona

Southwest Ground-water Consultants Inc. - Report Task No. 5 – Recharge Mapping – Upper Verde River Watershed Protection Coalition

USGS - Geologic Map of the Prescott National Forest and the Headwaters Of the Verde River, Yavapai and Coconino Counties, Arizona

VI. Appendix

Drainage Basin, Land Use, and Soil Maps

Figure 8. Drainage Basin Map

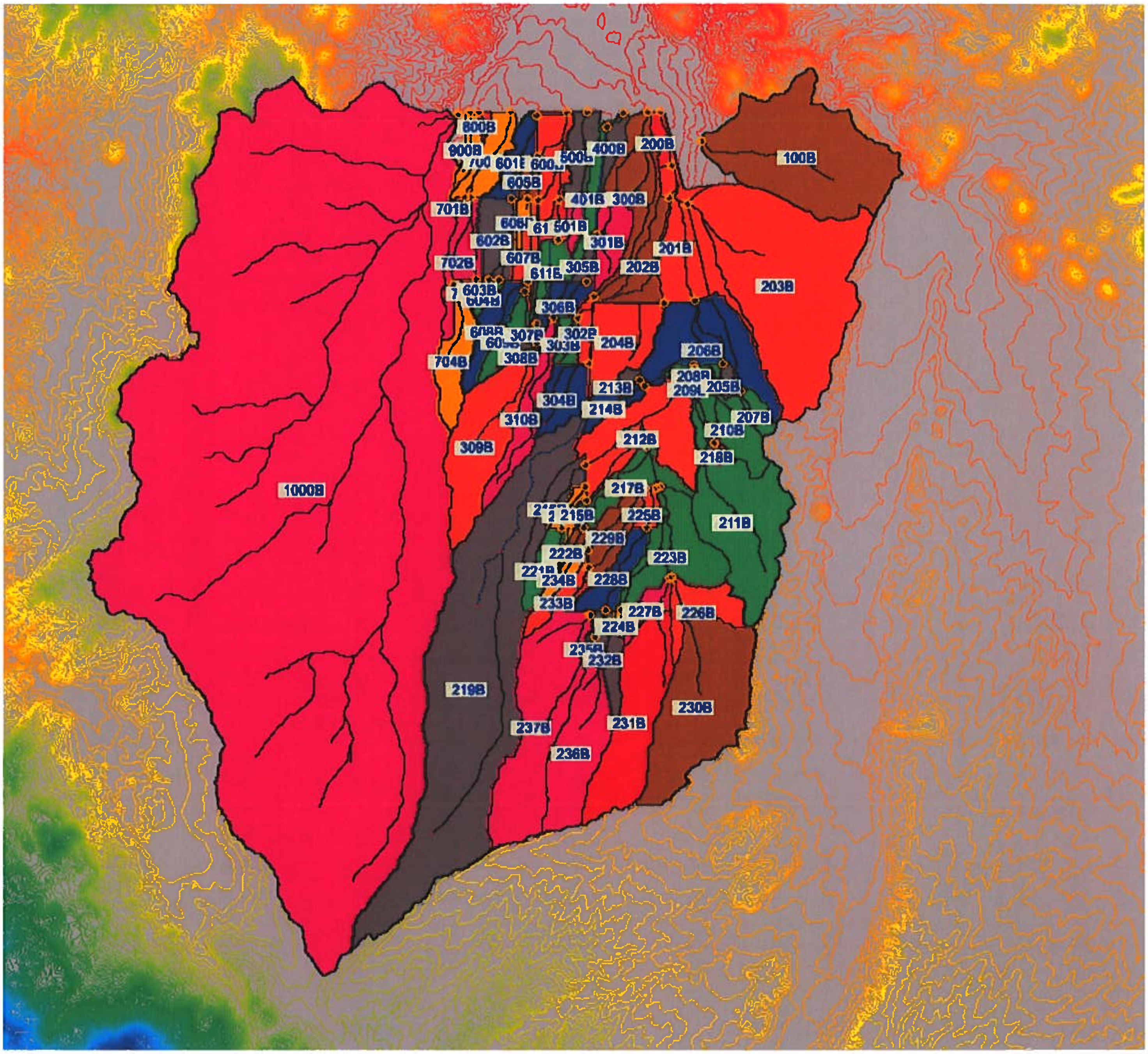


Figure 9. Land Use Category Map

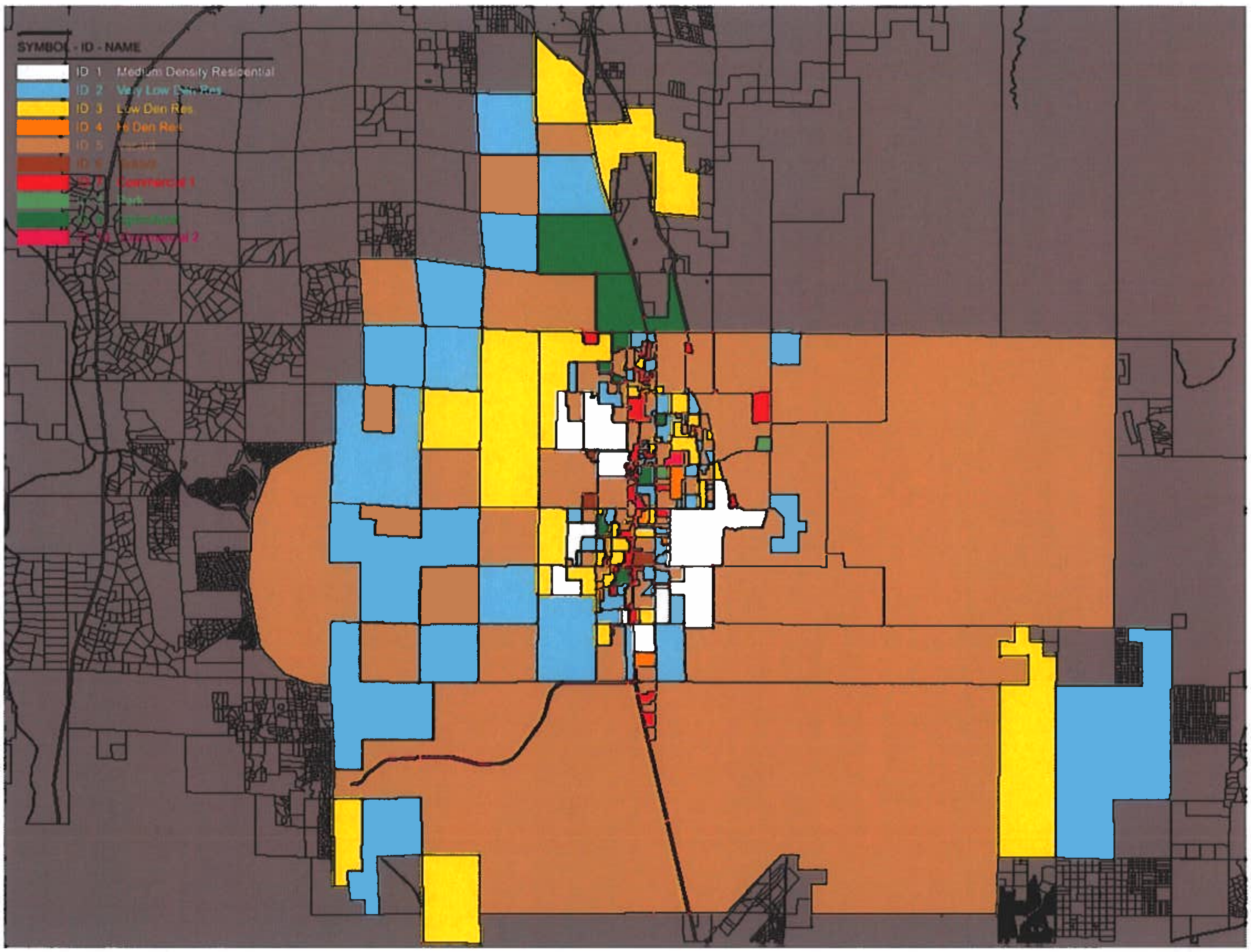


Figure 10. Soil Type Map

Detailed Soil Descriptions

Yavapai County, Arizona, Western Part

LwD—Luzena cobbly loam, 0 to 30 percent slopes

Map Unit Setting

Elevation: 4,000 to 6,200 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 50 to 57 degrees F
Frost-free period: 160 to 220 days

Map Unit Composition

Luzena and similar soils: 90 percent

Description of Luzena

Setting

Landform: Hills
Landform position (two-dimensional): Toeslope, backslope, summit
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Residuum and/or colluvium derived from andesite and/or rhyolite and/or tuff

Properties and qualities

Slope: 0 to 30 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water capacity: Very low (about 1.7 inches)

Interpretive groups

Land capability (nonirrigated): 6e
Ecological site: Volcanic Hills 12-16" p.z. Clayey (R038XA117AZ)

Typical profile

0 to 3 inches: Cobbly loam
3 to 14 inches: Gravelly clay
14 to 17 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

Lz—Lynx soils, wet variant

Map Unit Setting
- *Elevation:* 4,000 to 6,000 feet
- *Mean annual precipitation:* 12 to 16 inches
- *Mean annual air temperature:* 51 to 57 degrees F
- *Frost-free period:* 140 to 220 days

Map Unit Composition
- *Lynx, variant, and similar soils:* 50 percent
- *Lynx, variant, and similar soils:* 35 percent

Description of Lynx, Variant

Setting
- *Landform:* Flood plains, swales
- *Landform position (two-dimensional):* Summit
- *Landform position (three-dimensional):* Dip
- *Down-slope shape:* Linear
- *Across-slope shape:* Linear
- *Parent material:* Mixed alluvium

Properties and qualities
- *Slope:* 0 to 1 percent
- *Depth to restrictive feature:* More than 80 inches
- *Drainage class:* Well drained
- *Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.57 in/hr)
- *Depth to water table:* About 24 to 36 inches
- *Frequency of flooding:* Occasional
- *Frequency of ponding:* None
- *Calcium carbonate, maximum content:* 5 percent
- *Available water capacity:* High (about 10.6 inches)

Interpretive groups
- *Land capability classification (irrigated):* 1
- *Land capability (nonirrigated):* 6c
- *Ecological site:* Meadow 12-16" p.z. (R038XA110AZ)

Typical profile
- *0 to 16 inches:* Loam
- *16 to 60 inches:* Clay loam

Description of Lynx, Variant

Setting
- *Landform:* Swales, flood plains
- *Landform position (two-dimensional):* Summit
- *Landform position (three-dimensional):* Dip
- *Down-slope shape:* Linear
- *Across-slope shape:* Linear
- *Parent material:* Mixed alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 24 to 36 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 3.0
Available water capacity: High (about 10.9 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability (nonirrigated): 6c
Ecological site: Meadow 12-16" p.z. (R038XA110AZ)

Typical profile

0 to 16 inches: Clay loam
16 to 60 inches: Clay loam

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

Ly—Lynx soils

Map Unit Setting

Elevation: 4,000 to 6,000 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 51 to 57 degrees F
Frost-free period: 140 to 220 days

Map Unit Composition

Lynx and similar soils: 45 percent
Lynx and similar soils: 40 percent

Description of Lynx

Setting

Landform: Drainageways, alluvial fans
Landform position (two-dimensional): Summit, backslope, toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave, linear
Across-slope shape: Linear, convex
Parent material: Mixed alluvium

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Available water capacity: High (about 10.6 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability (nonirrigated): 6c
Ecological site: Loamy Bottom 12-16" p.z. (R038XA107AZ)

Typical profile

0 to 14 inches: Loam
14 to 60 inches: Clay loam

Description of Lynx

Setting

Landform: Alluvial fans, drainageways
Landform position (two-dimensional): Summit, toeslope, backslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Convex, linear
Parent material: Mixed alluvium

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 3.0
Available water capacity: High (about 10.9 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability (nonirrigated): 6c
Ecological site: Loamy Bottom 12-16" p.z. (R038XA107AZ)

Typical profile

0 to 14 inches: Clay loam
14 to 60 inches: Clay loam

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

MgD—Moano gravelly loam, 0 to 30 percent slopes

Map Unit Setting

Elevation: 4,000 to 5,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 50 to 57 degrees F
Frost-free period: 140 to 200 days

Map Unit Composition

Moano and similar soils: 85 percent

Description of Moano

Setting

Landform: Hills
Landform position (two-dimensional): Toeslope, backslope, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Residuum and/or colluvium derived from schist

Properties and qualities

Slope: 0 to 30 percent
Depth to restrictive feature: 6 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.0 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Ecological site: Granitic Hills 12-16" p.z. (R038XA104AZ)

Typical profile

0 to 9 inches: Gravelly loam
9 to 16 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

MkF—Moano very rocky loam, 15 to 60 percent slopes

Map Unit Setting

Elevation: 4,000 to 5,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 50 to 57 degrees F
Frost-free period: 140 to 200 days

Map Unit Composition

Moano and similar soils: 70 percent
Rock outcrop: 20 percent

Description of Moano

Setting

Landform: Hills, mountains
Landform position (two-dimensional): Backslope, summit, toeslope
Landform position (three-dimensional): Mountainflank, side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Residuum and/or colluvium derived from schist

Properties and qualities

Slope: 15 to 60 percent
Depth to restrictive feature: 6 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.0 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Ecological site: Granitic Hills 12-16" p.z. (R038XA104AZ)

Typical profile

0 to 2 inches: Gravelly loam
2 to 9 inches: Gravelly loam
9 to 16 inches: Unweathered bedrock

Description of Rock Outcrop

Interpretive groups

Land capability (nonirrigated): 8

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

MrC—Moano-Lynx association, rolling

Map Unit Setting

Elevation: 4,000 to 5,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 51 to 57 degrees F
Frost-free period: 140 to 200 days

Map Unit Composition

Moano and similar soils: 60 percent
Lynx and similar soils: 30 percent

Description of Moano

Setting

Landform: Hills
Landform position (two-dimensional): Summit, toeslope, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Residuum and/or colluvium derived from schist

Properties and qualities

Slope: 8 to 20 percent
Depth to restrictive feature: 6 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.0 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Ecological site: Granitic Hills 12-16" p.z. (R038XA104AZ)
Other vegetative classification: Granitic Hills 12-16" p.z. (038XA104AZ)

Typical profile

0 to 9 inches: Gravelly loam
9 to 16 inches: Unweathered bedrock

Description of Lynx

Setting

Landform: Drainageways, swales
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave, linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Available water capacity: High (about 10.6 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability (nonirrigated): 6e
Ecological site: Loamy Bottom 12-16" p.z. (R038XA107AZ)

Typical profile

0 to 14 inches: Loam
14 to 60 inches: Clay loam

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

PhD—Pastura complex, 1 to 30 percent slopes

Map Unit Setting

Elevation: 4,600 to 5,400 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 52 to 56 degrees F
Frost-free period: 140 to 170 days

Map Unit Composition

Pastura and similar soils: 50 percent
Pastura and similar soils: 40 percent

Description of Pastura

Setting

Landform: Stream terraces, alluvial fans
Landform position (two-dimensional): Summit, toeslope, backslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium derived from limestone and sandstone

Properties and qualities

Slope: 1 to 8 percent
Depth to restrictive feature: 8 to 20 inches to petrocalcic
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0
Available water capacity: Very low (about 1.6 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Ecological site: Limy Upland 10-14" p.z. Shallow (R035XA125AZ)

Typical profile

0 to 2 inches: Gravelly loam
2 to 11 inches: Gravelly loam
11 to 19 inches: Indurated

Description of Pastura

Setting

Landform: Stream terraces, alluvial fans
Landform position (two-dimensional): Backslope, summit, toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear

Across-slope shape: Convex
Parent material: Alluvium derived from limestone and sandstone

Properties and qualities
Slope: 8 to 30 percent
Depth to restrictive feature: 8 to 20 inches to petrocalcic
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 15.0
Available water capacity: Very low (about 1.7 inches)

Interpretive groups
Land capability (nonirrigated): 7s
Ecological site: Limy Upland 10-14" p.z. Shallow (R035XA125AZ)

Typical profile
0 to 2 inches: Cobbly loam
2 to 11 inches: Gravelly loam
11 to 19 inches: Indurated

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

PmB—Pastura-Lynx association, undulating

Map Unit Setting

Elevation: 4,600 to 5,400 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 52 to 56 degrees F
Frost-free period: 140 to 170 days

Map Unit Composition

Pastura and similar soils: 60 percent
Lynx and similar soils: 30 percent

Description of Pastura

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Summit, toeslope, backslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium derived from limestone and sandstone

Properties and qualities

Slope: 1 to 8 percent
Depth to restrictive feature: 8 to 20 inches to petrocalcic
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0
Available water capacity: Very low (about 1.6 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Ecological site: Limy Upland 10-14" p.z. Shallow (R035XA125AZ)

Typical profile

0 to 2 inches: Gravelly loam
2 to 11 inches: Gravelly loam
11 to 19 inches: Indurated

Description of Lynx

Setting

Landform: Swales, drainageways
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave

Across-slope shape: Linear
Parent material: Mixed alluvium

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Available water capacity: High (about 10.6 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability (nonirrigated): 6e
Ecological site: Loamy Bottom 10-14" p.z. (R035XA112AZ)

Typical profile

0 to 14 inches: Loam
14 to 60 inches: Clay loam

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

Po—Poley gravelly sandy loam

Map Unit Setting
Elevation: 4,800 to 5,600 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition
Poley and similar soils: 90 percent

Description of Poley

Setting
Landform: Plains, alluvial fans
Landform position (two-dimensional): Summit, toeslope, backslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium derived from limestone and sandstone

Properties and qualities
Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0
Available water capacity: Low (about 5.8 inches)

Interpretive groups
Land capability classification (irrigated): 3s
Land capability (nonirrigated): 6s
Ecological site: Loamy Upland 10-14" p.z. (R035XA113AZ)

Typical profile
0 to 2 inches: Gravelly sandy loam
2 to 6 inches: Sandy clay loam
6 to 18 inches: Clay
18 to 24 inches: Sandy clay loam

Description of Poley

Setting

Landform: Alluvial fans, swales
Landform position (two-dimensional): Summit, toeslope, backslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: Alluvium derived from limestone and sandstone

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0
Available water capacity: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability (nonirrigated): 6s
Ecological site: Loamy Upland 12-16" p.z. (R038XA109AZ)
Other vegetative classification: Loamy Upland 12-16" p.z. (038XA109AZ)

Typical profile

0 to 2 inches: Sandy loam
2 to 6 inches: Sandy clay loam
6 to 18 inches: Clay
18 to 24 inches: Sandy clay loam
24 to 60 inches: Very cobbly coarse sandy loam

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

24 to 60 inches: Very cobbly coarse sandy loam

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

Ro—Rock land

Map Unit Composition
Rock land: 90 percent

Description of Rock Land

Interpretive groups
Land capability (nonirrigated): 8

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

Sa—Sandy and Gravelly alluvial land

Map Unit Composition

Gravelly alluvial land: 0 percent
Sandy alluvial land: 0 percent

Description of Sandy Alluvial Land

Interpretive groups

Land capability (nonirrigated): 8
Ecological site: Sandy Bottom 16-20" p.z. (R038XB211AZ)

Description of Gravelly Alluvial Land

Interpretive groups

Land capability (nonirrigated): 8
Ecological site: Sandy Bottom 16-20" p.z. (R038XB211AZ)

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

SlB—Springerville cobbly clay, 0 to 8 percent slopes

Map Unit Setting

Elevation: 4,200 to 7,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 115 to 225 days

Map Unit Composition

Springerville and similar soils: 90 percent

Description of Springerville

Setting

Landform: Plains
Landform position (two-dimensional): Summit, toeslope, backslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium and/or colluvium derived from basalt and/or cinders

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 28 to 70 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Available water capacity: Low (about 5.8 inches)

Interpretive groups

Land capability (nonirrigated): 6s
Ecological site: Clayey Upland 14-18" p.z. (R035XG706AZ)

Typical profile

0 to 4 inches: Cobbly clay
4 to 35 inches: Silty clay
35 to 39 inches: Stony silty clay
39 to 50 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

SmB—Springerville very stony clay, 0 to 8 percent slopes

Map Unit Setting

Elevation: 4,200 to 7,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 115 to 225 days

Map Unit Composition

Springerville and similar soils: 95 percent

Description of Springerville

Setting

Landform: Plains
Landform position (two-dimensional): Backslope, summit, toeslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium and/or colluvium derived from basalt and/ or cinders

Properties and qualities

Slope: 0 to 8 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 28 to 70 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Available water capacity: Low (about 5.7 inches)

Interpretive groups

Land capability (nonirrigated): 6s
Ecological site: Clayey Upland 14-18" p.z. (R035XG706AZ)

Typical profile

0 to 4 inches: Very stony clay
4 to 35 inches: Silty clay
35 to 39 inches: Stony silty clay
39 to 50 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

SnD—Springerville-Cabezon complex, 3 to 30 percent slopes

Map Unit Setting

Elevation: 4,800 to 7,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 118 to 210 days

Map Unit Composition

Springerville and similar soils: 55 percent
Cabezon and similar soils: 15 percent
Cabezon and similar soils: 15 percent

Description of Springerville

Setting

Landform: Plains, hills
Landform position (two-dimensional): Toeslope, backslope, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium and/or colluvium derived from basalt and/or cinders

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 28 to 70 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Available water capacity: Low (about 5.8 inches)

Interpretive groups

Land capability (nonirrigated): 6s
Ecological site: Clayey Upland 14-18" p.z. (R035XG706AZ)

Typical profile

0 to 4 inches: Cobbly clay
4 to 35 inches: Silty clay
35 to 39 inches: Stony silty clay
39 to 50 inches: Unweathered bedrock

Description of Cabezon

Setting

Landform: Plains, hills
Landform position (two-dimensional): Backslope, summit, toeslope
Landform position (three-dimensional): Side slope

Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium derived from basalt and/or colluvium derived from basalt

Properties and qualities

Slope: 15 to 30 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 7 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.6 inches)

Interpretive groups

Land capability (nonirrigated): 6s
Ecological site: Shallow Loamy 14-18" p.z. (R035XG717AZ)

Typical profile

0 to 1 inches: Clay loam
1 to 12 inches: Cobbly clay
12 to 24 inches: Unweathered bedrock

Description of Cabezon

Setting

Landform: Plains, hills
Landform position (two-dimensional): Backslope, summit, toeslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium derived from basalt and/or colluvium derived from basalt

Properties and qualities

Slope: 8 to 15 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 7 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.5 inches)

Interpretive groups

Land capability (nonirrigated): 6s
Ecological site: Shallow Loamy 14-18" p.z. (R035XG717AZ)

Typical profile

0 to 1 inches: Very stony clay loam
1 to 12 inches: Cobbly clay

12 to 24 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

TaB—Tajo gravelly loam, 0 to 8 percent slopes

Map Unit Setting

Elevation: 5,000 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Tajo and similar soils: 90 percent

Description of Tajo

Setting

Landform: Plains
Landform position (two-dimensional): Toeslope, backslope, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium and/or colluvium derived from basalt and/or cinders

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 20 to 40 inches to petrocalcic; 60 to 70 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0
Available water capacity: Low (about 4.3 inches)

Interpretive groups

Land capability (nonirrigated): 6s
Ecological site: Clay Loam Upland 10-14" p.z. (R035XA107AZ)

Typical profile

0 to 3 inches: Gravelly loam
3 to 28 inches: Clay loam
28 to 40 inches: Cemented
40 to 46 inches: Indurated
46 to 63 inches: Cemented

63 to 73 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

TdC—Thunderbird cobbly clay loam, 0 to 15 percent slopes

Map Unit Setting

Elevation: 4,000 to 7,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 52 to 56 degrees F
Frost-free period: 120 to 210 days

Map Unit Composition

Thunderbird and similar soils: 85 percent

Description of Thunderbird

Setting

Landform: Hills
Landform position (two-dimensional): Backslope, summit, toeslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium derived from basalt and/or colluvium derived from basalt

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 4.8 inches)

Interpretive groups

Land capability (nonirrigated): 6s
Ecological site: Clay Loam Upland 12-16" p.z. (R038XA103AZ)

Typical profile

0 to 2 inches: Cobbly clay loam
2 to 28 inches: Clay
28 to 31 inches: Gravelly clay loam
31 to 33 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

TdE—Thunderbird cobbly clay loam, 15 to 40 percent slopes

Map Unit Setting

Elevation: 4,000 to 7,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 52 to 56 degrees F
Frost-free period: 120 to 210 days

Map Unit Composition

Thunderbird and similar soils: 85 percent

Description of Thunderbird

Setting

Landform: Mesas, hills
Landform position (two-dimensional): Backslope, summit, toeslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium derived from basalt and/or colluvium derived from basalt

Properties and qualities

Slope: 15 to 40 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 4.8 inches)

Interpretive groups

Land capability (nonirrigated): 6s
Ecological site: Clayey Slopes 12-16" p.z. (R038XA108AZ)

Typical profile

0 to 2 inches: Cobbly clay loam
2 to 28 inches: Clay
28 to 31 inches: Gravelly clay loam
31 to 33 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

TmD—Tortugas very rocky loam, 8 to 30 percent slopes

Map Unit Setting

Elevation: 4,000 to 6,000 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 120 to 200 days

Map Unit Composition

Tortugas and similar soils: 70 percent
Rock outcrop: 20 percent

Description of Tortugas

Setting

Landform: Hills
Landform position (two-dimensional): Summit, toeslope, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Residuum and/or colluvium derived from limestone

Properties and qualities

Slope: 8 to 30 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 6 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 50 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0
Available water capacity: Very low (about 0.9 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Ecological site: Shallow Loamy 10-14" p.z. (R035XA119AZ)

Typical profile

0 to 9 inches: Very stony loam
9 to 10 inches: Unweathered bedrock

Description of Rock Outcrop

Interpretive groups

Land capability (nonirrigated): 8

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

VtE—Venezia-Thunderbird complex, 15 to 40 percent slopes

Map Unit Setting

Elevation: 4,000 to 5,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 52 to 56 degrees F
Frost-free period: 140 to 210 days

Map Unit Composition

Venezia and similar soils: 60 percent
Thunderbird and similar soils: 30 percent

Description of Venezia

Setting

Landform: Hills
Landform position (two-dimensional): Toeslope, backslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Residuum weathered from basalt and/or colluvium derived from basalt

Properties and qualities

Slope: 15 to 40 percent
Depth to restrictive feature: 5 to 16 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.7 inches)

Interpretive groups

Land capability (nonirrigated): 6s
Ecological site: Volcanic Hills 12-16" p.z. Clayey (R038XA117AZ)

Typical profile

0 to 2 inches: Gravelly loam
2 to 10 inches: Loam
10 to 12 inches: Unweathered bedrock

Description of Thunderbird

Setting

Landform: Hills
Landform position (two-dimensional): Backslope, summit, toeslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex

Parent material: Alluvium derived from basalt and/or colluvium derived from basalt

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 4.8 inches)

Interpretive groups

Land capability (nonirrigated): 6s
Ecological site: Clayey Slopes 12-16" p.z. (R038XA108AZ)

Typical profile

0 to 2 inches: Cobbly clay loam
2 to 28 inches: Clay
28 to 31 inches: Gravelly clay loam
31 to 33 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 6, Aug 26, 2008

Yavapai County, Arizona, Western Part

Wp—Wineg and Poley soils

Map Unit Setting

Elevation: 4,800 to 5,600 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Poley and similar soils: 0 percent
Wineg and similar soils: 0 percent

Description of Wineg

Setting

Landform: Alluvial fans, swales
Landform position (two-dimensional): Summit, toeslope, backslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: Mixed alluvium

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0
Available water capacity: Moderate (about 6.4 inches)

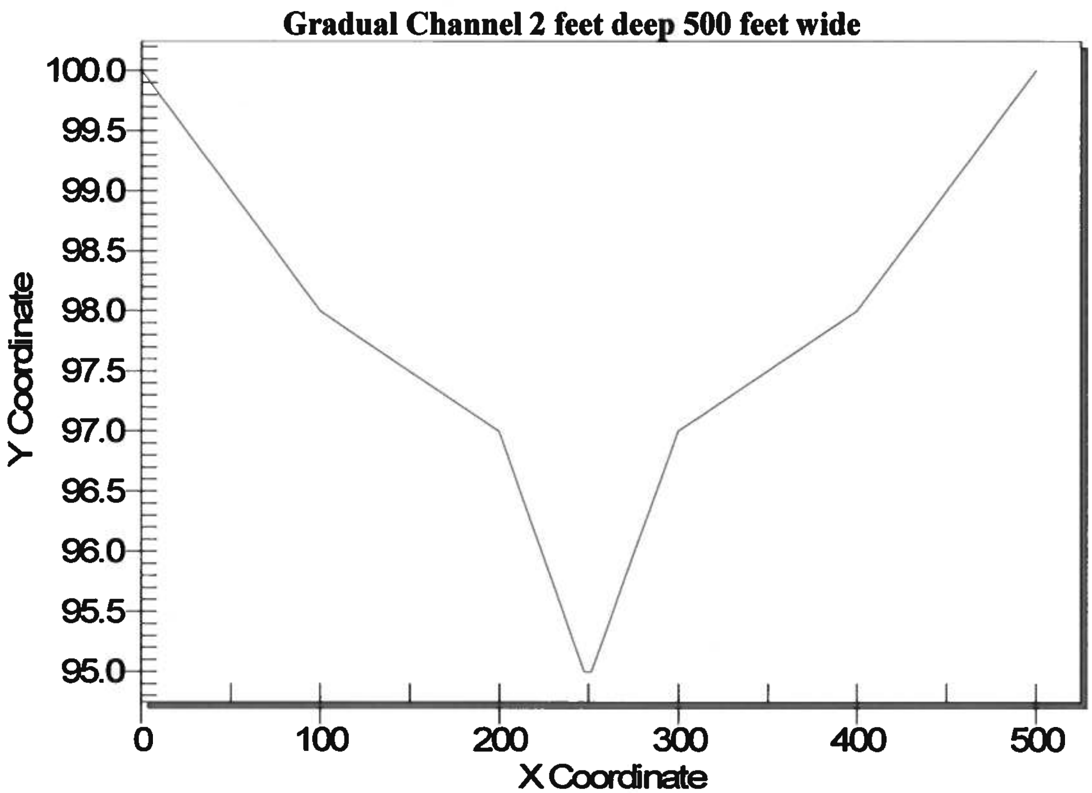
Interpretive groups

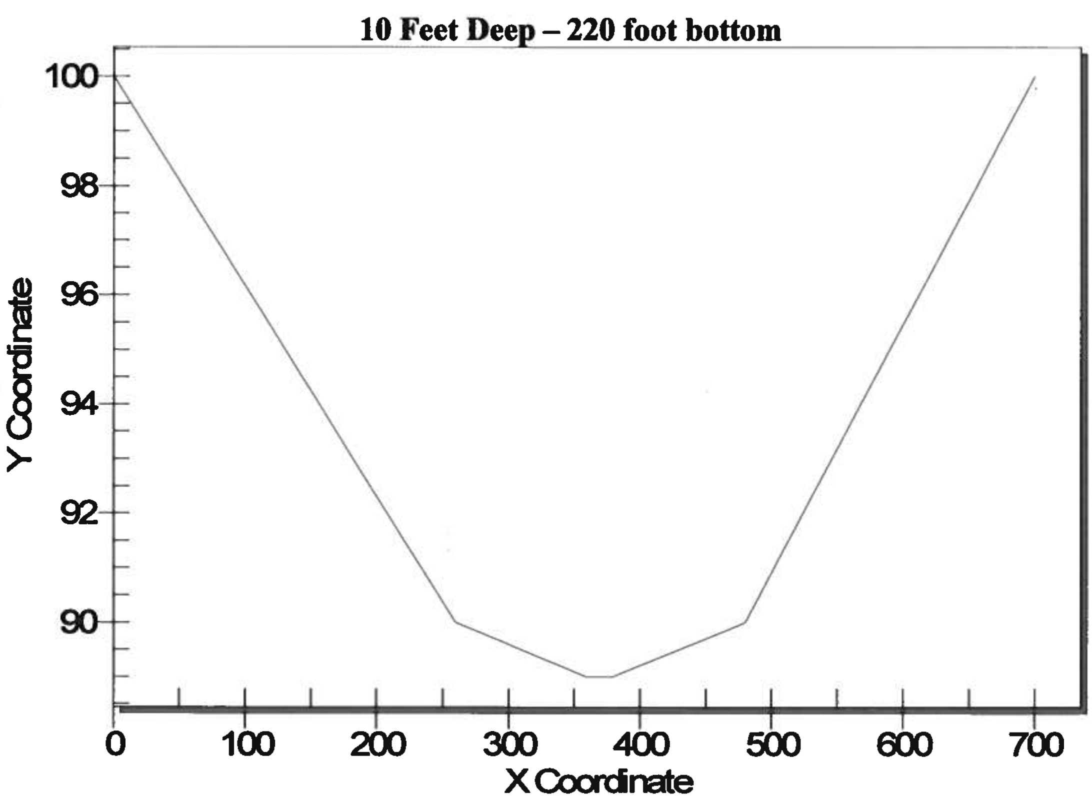
Land capability classification (irrigated): 3e
Land capability (nonirrigated): 6s
Ecological site: Loamy Upland 12-16" p.z. (R038XA109AZ)
Other vegetative classification: Limy Upland 12-16" p.z. (038XA106AZ)

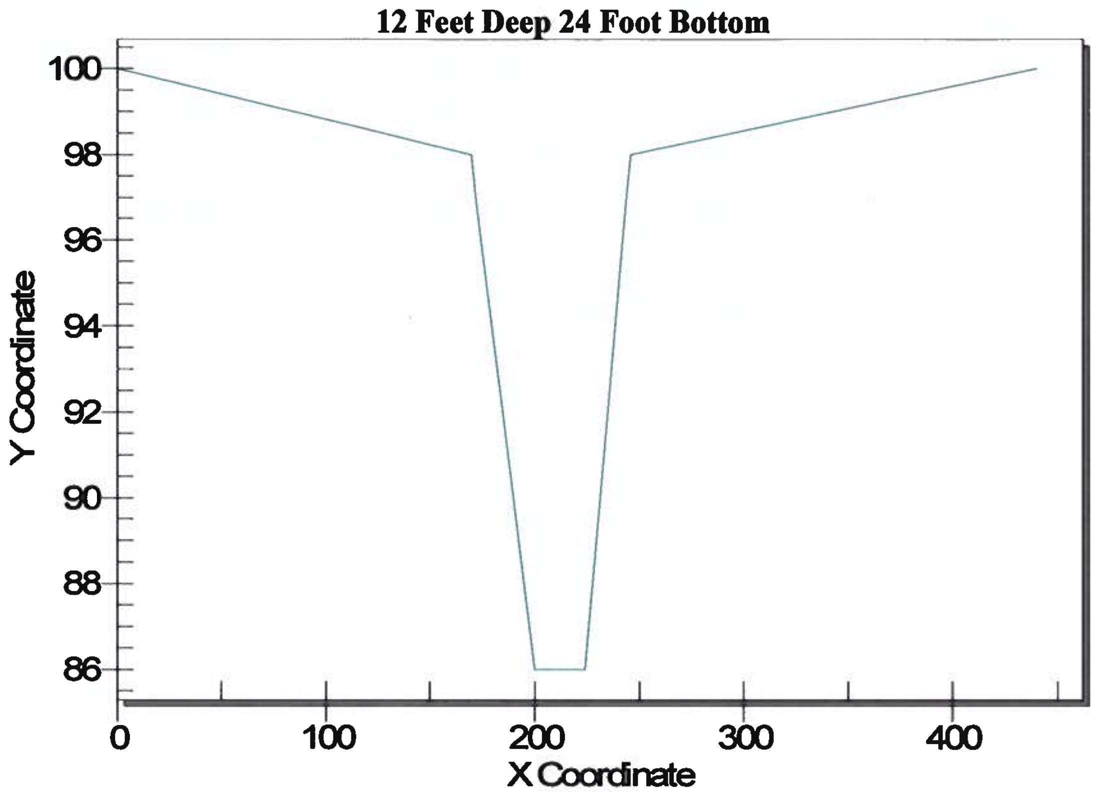
Typical profile

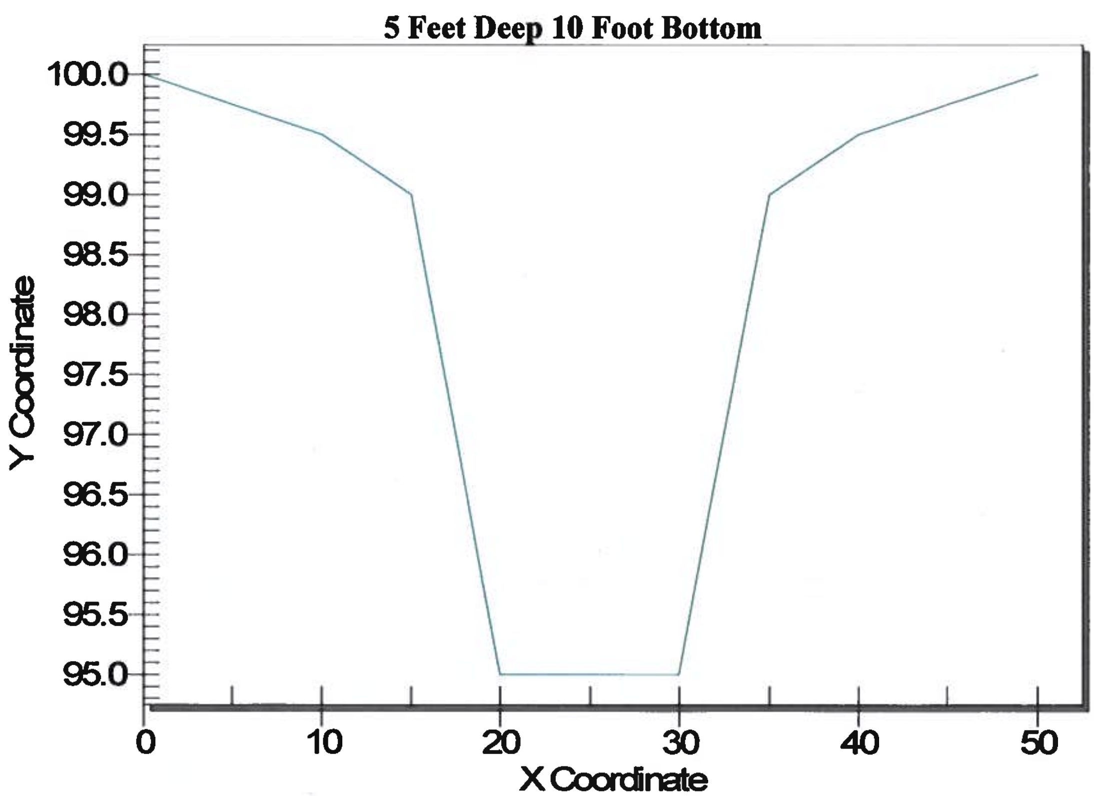
0 to 2 inches: Sandy loam
2 to 14 inches: Gravelly sandy clay loam
14 to 60 inches: Sandy loam

Generalized Channel Routing Sections

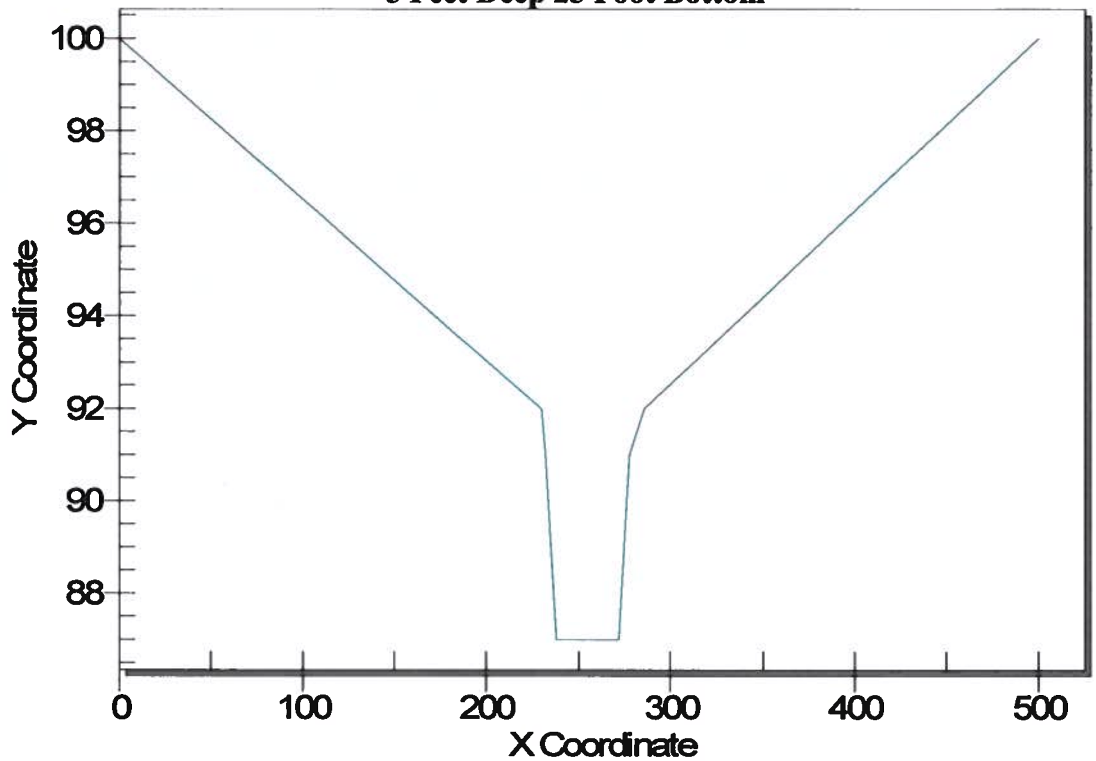

Gradual Channel 2 feet deep 500 feet wide
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.5
96.0
95.5
95.0
Y Coordinate
0
100
200
300
400
500
X Coordinate


10 Feet Deep – 220 foot bottom
100
98
96
94
92
90
Y Coordinate
0
100
200
300
400
500
600
700
X Coordinate

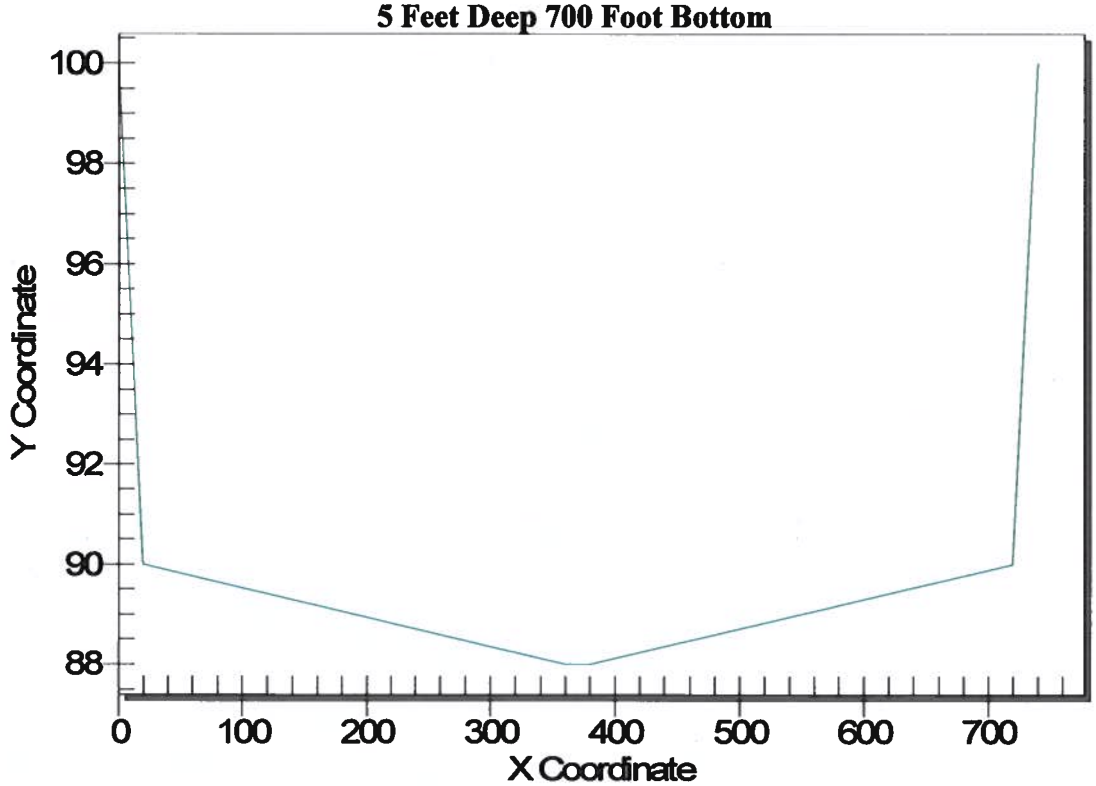

12 Feet Deep 24 Foot Bottom
Y Coordinate
100
98
96
94
92
90
88
86
0
100
200
300
400
X Coordinate


5 Feet Deep 10 Foot Bottom
Y Coordinate
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.5
96.0
95.5
95.0
0
10
20
30
40
50
X Coordinate

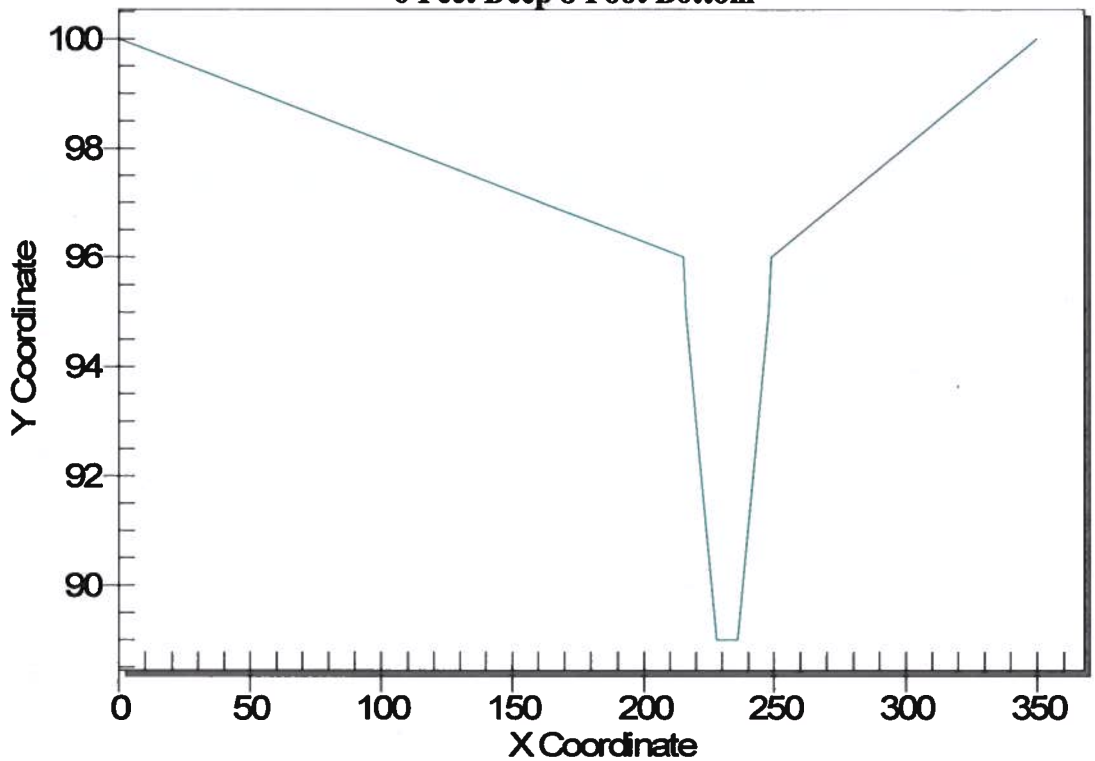
5 Feet Deep 25 Foot Bottom



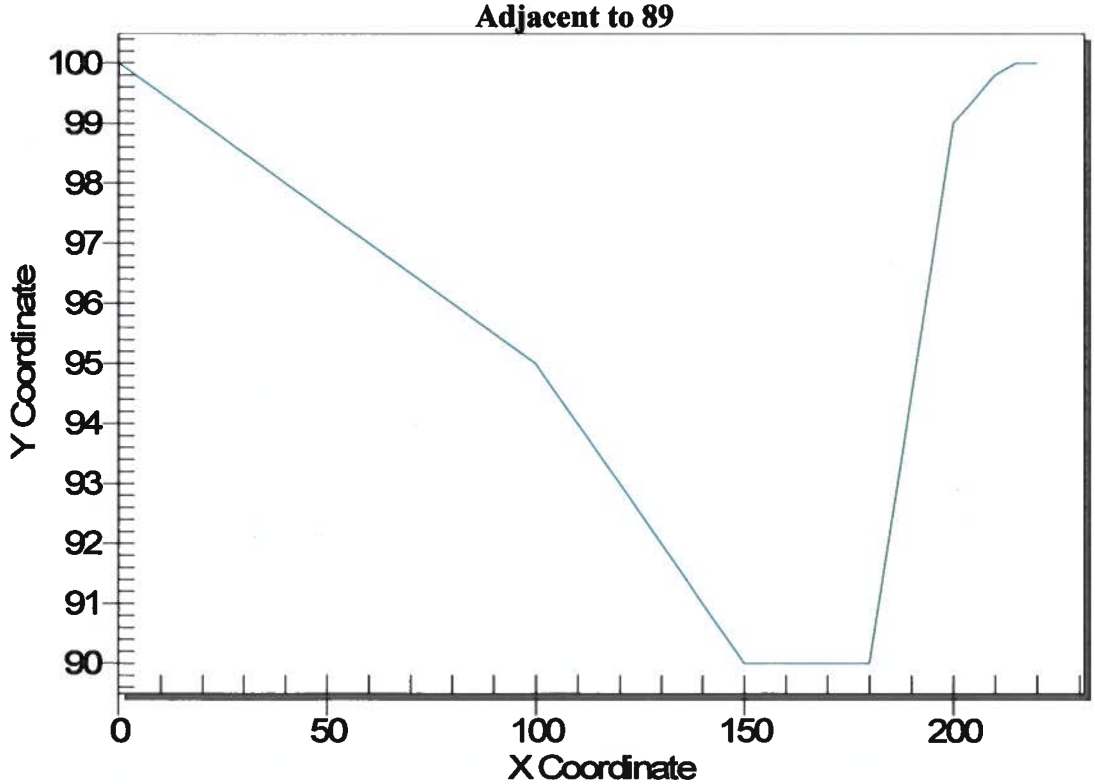
5 Feet Deep 700 Foot Bottom



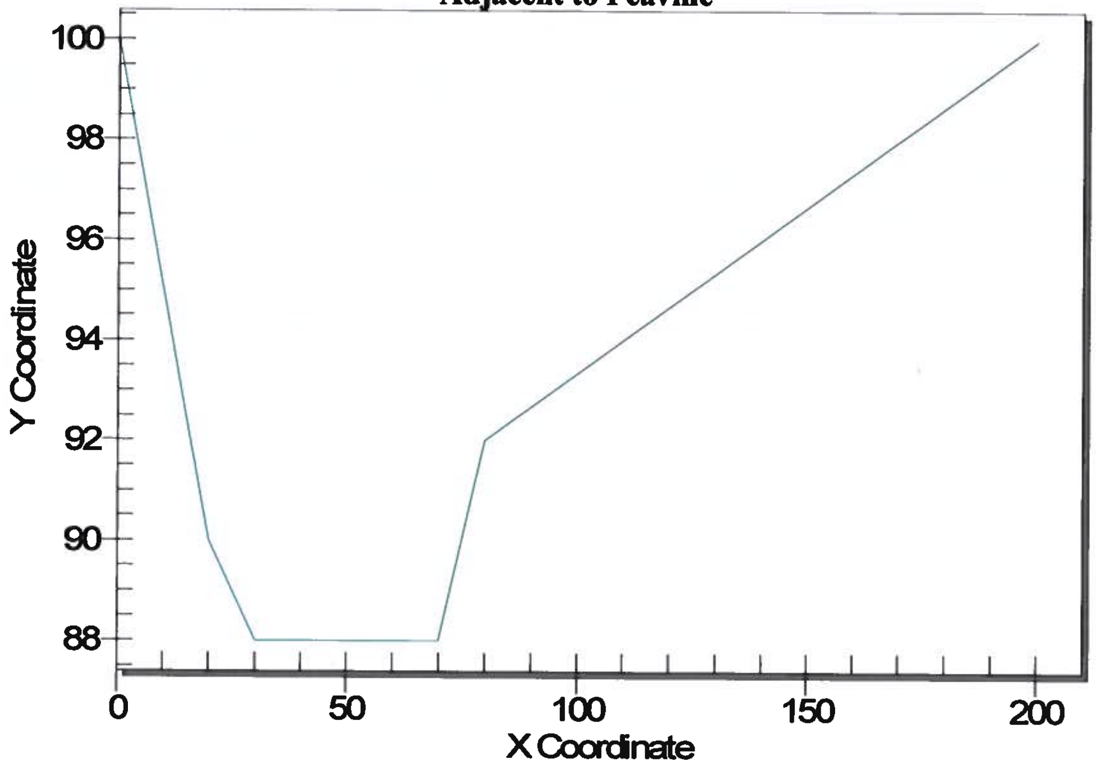
6 Feet Deep 8 Foot Bottom



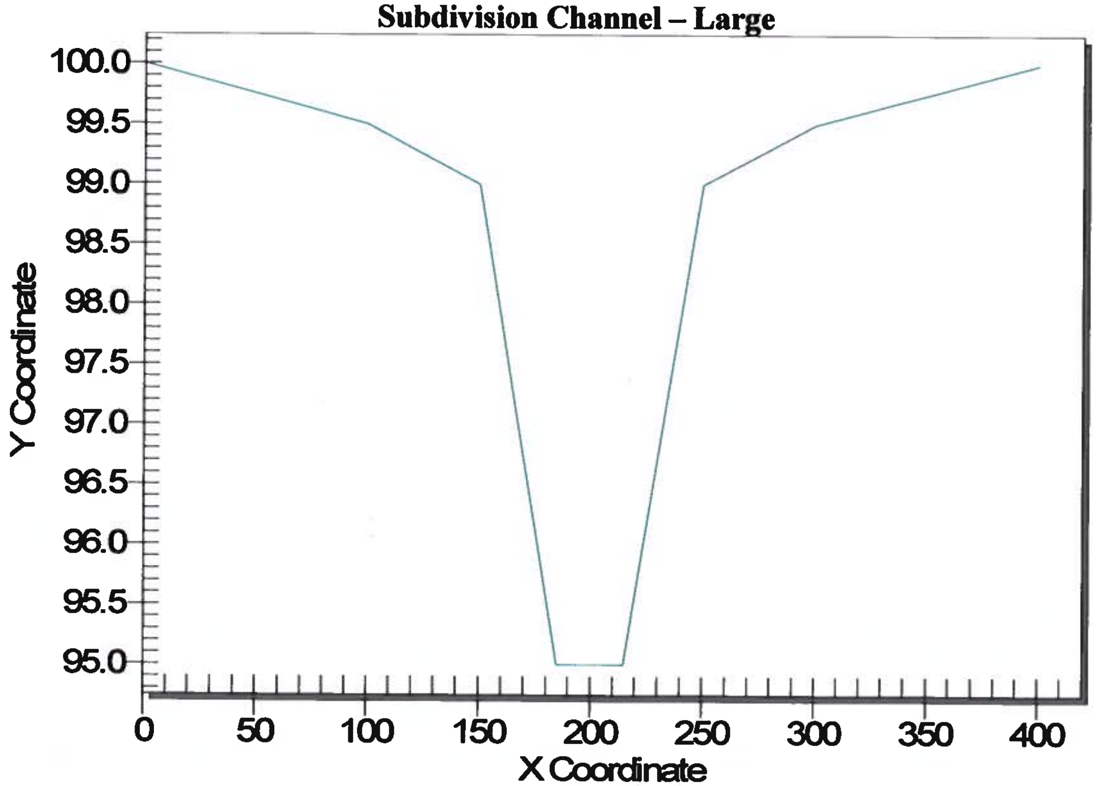
Adjacent to 89

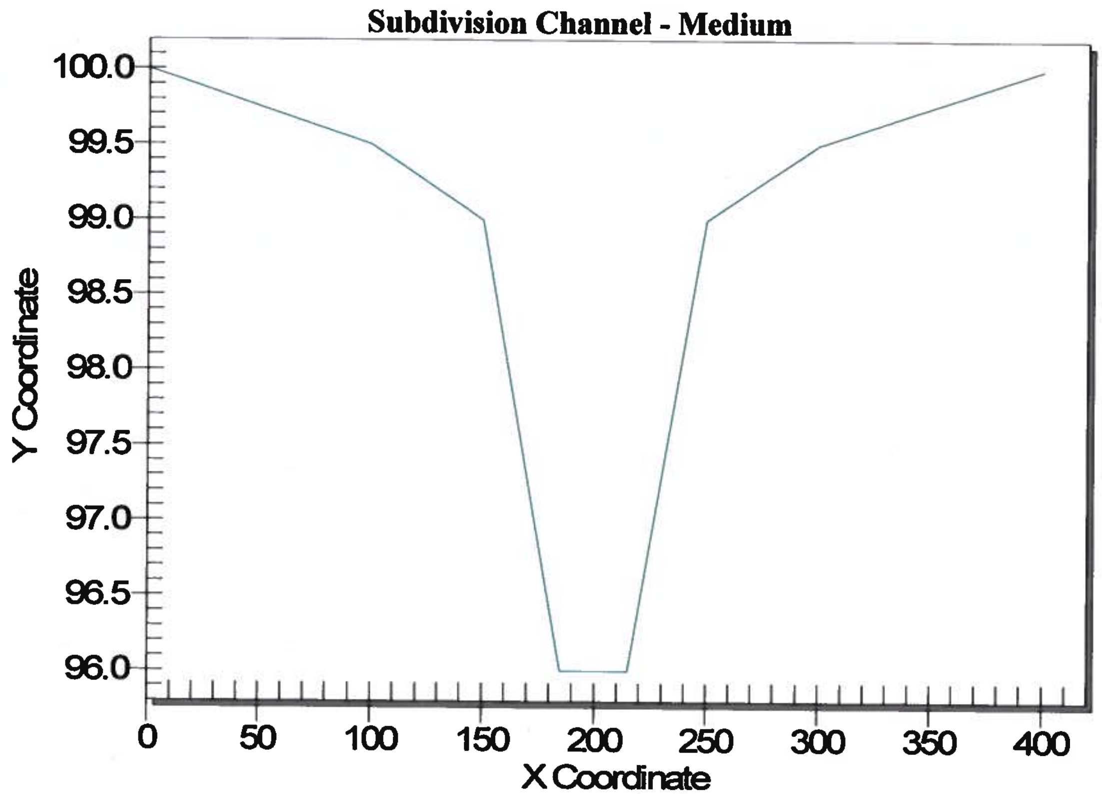


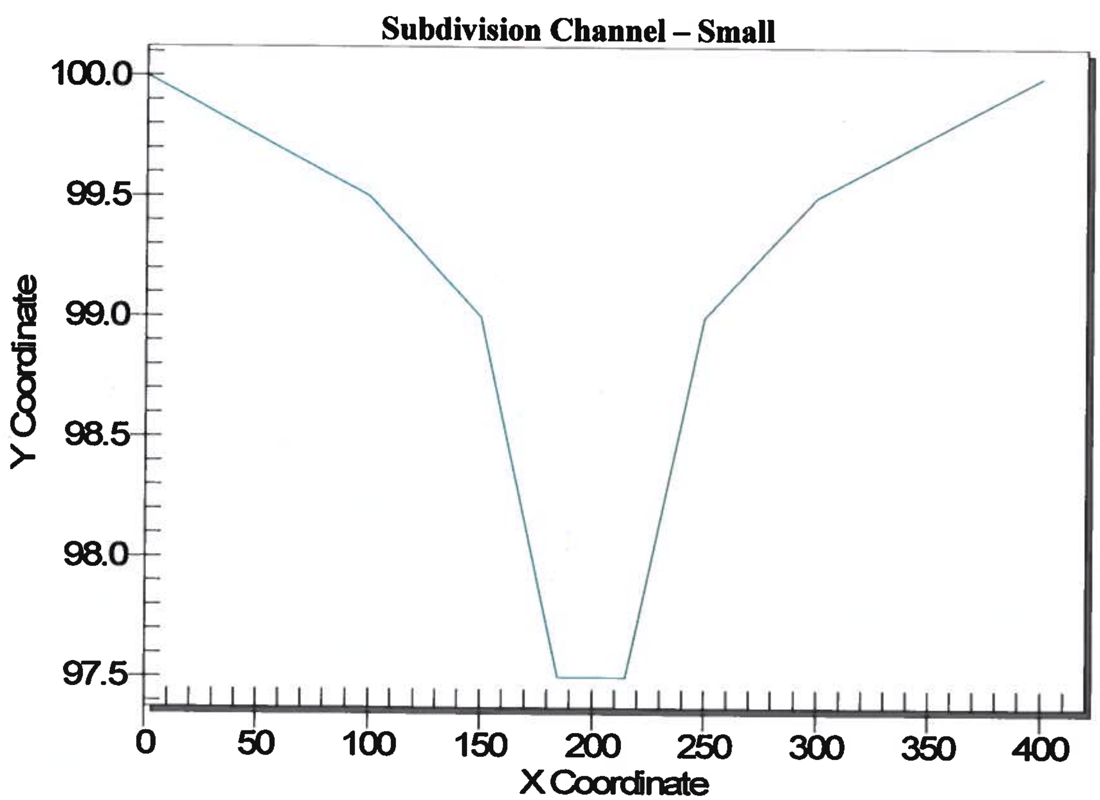
Adjacent to Peavine



Subdivision Channel – Large




Subdivision Channel - Medium
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.5
96.0
Y Coordinate
0
50
100
150
200
250
300
350
400
X Coordinate


Subdivision Channel – Small
100.0
99.5
99.0
98.5
98.0
97.5
Y Coordinate
0
50
100
150
200
250
300
350
400
X Coordinate

REPORT
TASK NO. 5
RECHARGE MAPPING

UPPER VERDE RIVER WATERSHED PROTECTION COALITION

Registered Professional Engineer (Geological)
CERTIFICATE NO.
10313
WILLIAM MURRAY
GREENSLADE
Date Signed 11/21/08
ARIZONA, U.S.A.

Expires: 12/31/2008

Submitted by

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November 21, 2008

1.0 INTRODUCTION

The Upper Verde River Watershed Protection Coalition (UVRWPC) authorized the performance of several work tasks to further the Coalition's goals. This report presents the results the *initial phase* of the Recharge Task (Task 5). The work was divided into two general topics: natural recharge areas and artificial recharge areas. Natural recharge is defined as the source areas and pathways for precipitation to reach the regional ground-water aquifers in the Big Chino Valley and Little Chino Valley subbasins. Artificial recharge areas are those that would facilitate the construction of recharge facilities to promote the movement of surface water or effluent into the regional aquifers. The focus of the natural recharge mapping was to identify the areas where recharge is occurring and delineate those areas that may warrant protection to ensure that natural recharge is not diminished. Artificial recharge mapping attempts to identify those areas where the surface and subsurface conditions are generally suitable for construction of recharge facilities.

The TAC recognized that in both the natural and artificial recharge areas, local soil and hydrogeologic conditions can and do materially affect the amount of recharge that occurs. For this reason, decisions to protect specific natural recharge areas or to site and construct individual artificial recharge projects require site-specific soil and hydrogeologic investigations. The purpose of this *initial phase* of the Recharge Task is to narrow the search to those areas that possess the general hydrogeologic, soils, and land use conditions that will promote a specific recharge objective (e.g. protection of natural recharge and/or facilitation of artificial recharge).

The *initial phase* scope of work was described in the Task Authorization Summary dated February 13, 2008 and is summarized below:

1. Compile the following data:

   - Natural recharge areas
   - Topography
   - Land ownership
   - Land use
   - Soil permeability

   The team will compile the above data from existing sources, no new mapping or field work is anticipated during this initial phase of work.

2. Develop preliminary base maps for presentation to the TAC. Map formats will be compatible with the existing Yavapai County GIS system.

3. Work closely with the TAC in developing both the data to be displayed and appropriate map scales.

4. Based on the foregoing work tasks, prepare maps that show:

- Natural recharge areas and current and proposed land uses
- Areas where soil permeability is favorable for artificial recharge

2.0 DATA SOURCES AND TYPES

Data were acquired from numerous sources, processed, and plotted using GIS software. Sources included:

- ADWR Printed Maps – playa deposit, artesian conditions, Big Chino alluvial basin boundaries.
- ADWR GWSI – depth to water readings
- ADWR Prescott AMA model – Recharge cell locations and quantities
- ADWR GIS Data CD – Little Chino Basin alluvial thickness, basins and sub-basins, watersheds, and sub-watersheds, county boundaries, HIA lands, 1994 water level contours
- ALRIS – Surface water drainage, land ownership
- FEMA – Q3 Flood Data – Digitized from FIRM's
- Southwest Ground-water Consultants – Upper Big Chino model recharge cell locations and Quantities, 2006 Upper Big Chino basin water level contours
- USDA/NRCS – Soil survey
- USGS – 30M Digital Elevation Model, Stream flow gage locations, surface geology
- Yavapai County – parcel ownership
- Coconino County – parcel ownership

While existing information sources were used to support the analysis, the data were compiled in a way not previously attempted. The focus was on those data affecting natural and artificial recharge of the regional ground-water system in the Big Chino and Little Chino subbasins. Emphasis was placed on identifying the existing data sources, determining their applicability to defining recharge volume and capability, narrowing down larger data sets to the area of study for ease of access and compiling the data using GIS software. Data sources can be easily layered and analyzed at a regional scale or at a county parcel level.

3.0 NATURAL RECHARGE AREAS

All natural recharge to ground-water aquifers originates as precipitation (rainfall and snowmelt). Recent studies of the Upper Verde River headwaters area (USGS Scientific Investigations Report 2005-5198 *Hydrogeology of the Upper and Middle Verde River Watersheds, Central Arizona,* Figure 34) used excessive precipitation and stable isotopes to identify those areas of precipitation that supply the ground-water in the regional aquifers. These *recharge source areas* are shown on Figure 1.

Recharge source areas occur in the mountains surrounding the Big and Little Chino valleys and throughout the Little Chino Valley. Since the mountain areas are generally underlain by low permeability bedrock very little aquifer recharge occurs within the source areas. Most of the recharge occurs as mountain front and/or stream channel recharge. Precipitation that originates in the recharge source areas flows as surface water into the adjacent Big Chino or Little Chino Valley where it crosses the Quaternary alluvium (clay, silt, sand and gravel) that comprise the upper surface of the regional aquifers of the valleys. The surface water infiltrates near the mountain fronts where sediments are generally coarser than on the valley floors and/or in ephemeral stream channels following major storm events. Little recharge occurs on the valley floors where evapotranspiration exceeds precipitation. The area of Quaternary alluvium (Wilson, Moore, Cooper 1983), the approximate boundary of the Big Chino aquifer (ADWR Map Series Report No. 28, 1995 the approximate boundary of the Little Chino aquifer, (200 feet alluvial thickness contour, ADWR GIS Data CD, 1999) and the location of major ephemeral steam channels, as defined by the 100-year floodplain and floodways (FEMA Q3 Flood Data, 1995), are shown on Figure 2.

Figure 3 shows land ownership. Since the focus of the natural recharge mapping is to identify areas where protection of natural recharge may be needed, lands that are subject to future land use change are considered to be more likely to require protection than those lands that are held in public trust such as U.S. Forest Service, National Park, Arizona Fish and Game and The Nature Conservancy lands.

Ground-water flow models of the Upper Big Chino and the Little Chino subbasins have assisted in identifying where mountain front and stream channel recharge is occurring. No published models of the middle portion of the Big Chino Valley are available. Areas of modeled recharge are shown on Figure 4.

Based on the data compiled above, the following criteria were developed to identify the areas of significant natural recharge and qualitatively define areas of potential protection.

1. Most recharge occurs near the mountain fronts and in stream channels
2. Modeling indicates that mountain front recharge is not evenly distributed, with some areas contributing more than others
3. Subsurface hydrogeologic conditions limit recharge area to the regional aquifers in select areas such as the playa deposit in the Big Chino subbasin and the artesian area in the Little Chino subbasin.
4. Recharge areas within public trust lands are lower priority for possible protection than those in private and state owned lands.

Utilizing the above criteria, areas of highest priority for potential protection are shown, in brown, on Figure 5. Areas identified include all major ephemeral stream channels and select mountain front areas where the amount of annual recharge is relatively large and the land is in private or state ownership.

As noted in the INTRODUCTION, local soil and hydrogeologic conditions can and do materially affect the amount of recharge that occurs. For this reason, decisions to protect specific natural recharge areas require site-specific soil and hydrogeologic investigations. The purpose of this *initial phase* of the Recharge Task is to narrow the search to those natural recharge areas that possess the general hydrogeologic, soils, and land use conditions that may warrant protection.

4.0 ARTIFICIAL RECHARGE AREAS

Artificial recharge in the study area is assumed to involve the injection of surface runoff or other water (e.g. effluent or imported water) into the regional aquifer. Typically this includes the construction of surface and/or subsurface facilities such as basins, pipelines and wells. For this *initial phase* the focus is on the mapping of surface features, although where key subsurface features are known, such as the depth to ground water, the playa deposit in the Big Chino subbasin and the artesian area in the Little Chino subbasin they are considered in the identification of areas potentially suitable for artificial recharge.

A key factor in the assessment of potential recharge areas is the permeability of the surface soils overlying the regional aquifers. U. S. Department of Agriculture soil survey data and maps of Western Yavapai County were reviewed. Soils were classified into permeability levels based on their associated estimated permeability, as follows:

Permeability Level	Estimated Permeability (in/hr)[1]
Low	0.2-0.6
Medium	0.6-2.0
High	>2.0

1. USDA 1976, Table 5 – *Estimated Soil Properties.*

Areas of shallow bedrock (<5 ft bgs) were considered to be unsuitable for recharge and were assigned a value of zero permeability. The distribution of soil permeability within the study area is shown on Figure 6.

A key factor in the siting of an artificial recharge facility is the depth to static ground water as this defines the ultimate volume of water that can be recharged. If the ground water table is shallow, recharge is limited by the potential rise in water levels to near land surface and the requirement to prevent "unreasonable harm" (e.g. waterlogging) to other land and water users. Typically the water level cannot rise to less than 20 ft below ground surface (ft bgs) at the point of compliance. For purposes of this study, areas with an existing depth-to-water of less than 100 ft bgs were identified as areas that are potentially unsuitable or at least require further site-specific investigation. Areas of shallow ground water (<100 ft bgs) are shown on Figure 7.

Soil survey data generally provide information for only the upper several feet of the subsurface. Deeper lithologic strata can materially affect the ability of recharged water to reach the regional aquifer. There are two known subsurface features that would limit the ability of recharged water to reach the regional aquifer: the playa deposit in the Big Chino subbasin and the artesian area in the Little Chino subbasin. These areas are shown on Figure 7.

Combining data on soil permeability, depth to water and known subsurface constraints yields a map of areas generally suitable for artificial recharge, as shown on Figure 8.

As noted previously, local soil and hydrogeologic conditions can and do materially affect the amount of recharge that can occur at any given recharge facility. This is one reason why site-specific investigations are required before selecting any potential artificial recharge site. In the case of artificial recharge it is also of critical importance to know the source of the water to be recharged. Technical feasibility and cost of transporting water is a key factor in determining the location of an artificial recharge facility. This *initial phase* of the recharge task narrows the search for areas that are suitable from a soils and hydrogeologic perspective.

Maps presented in the report are sized to fit on 81/2 by 11 inch paper. However, the GIS files underlying the maps are keyed to the Yavapai County GIS system and allow searches to the county parcel level. GIS files are presented on the enclosed CD.

5.0 RECOMMENDATIONS FOR FUTURE PROJECTS

Mapping of potential natural and artificial recharge areas in the Upper Verde River watershed provides an opportunity to narrow the focus of additional investigations into specific projects and project areas to promote the enhancement of ground-water recharge. The following is a list of potential projects for further investigation.

Natural Recharge

- Watershed/Grassland Management

  Review research on management techniques to reduce evapotranspiration and promote infiltration of precipitation. Support efforts to conserve open-space and grasslands, especially in the Big Chino subbasin.

- Land Development Policies

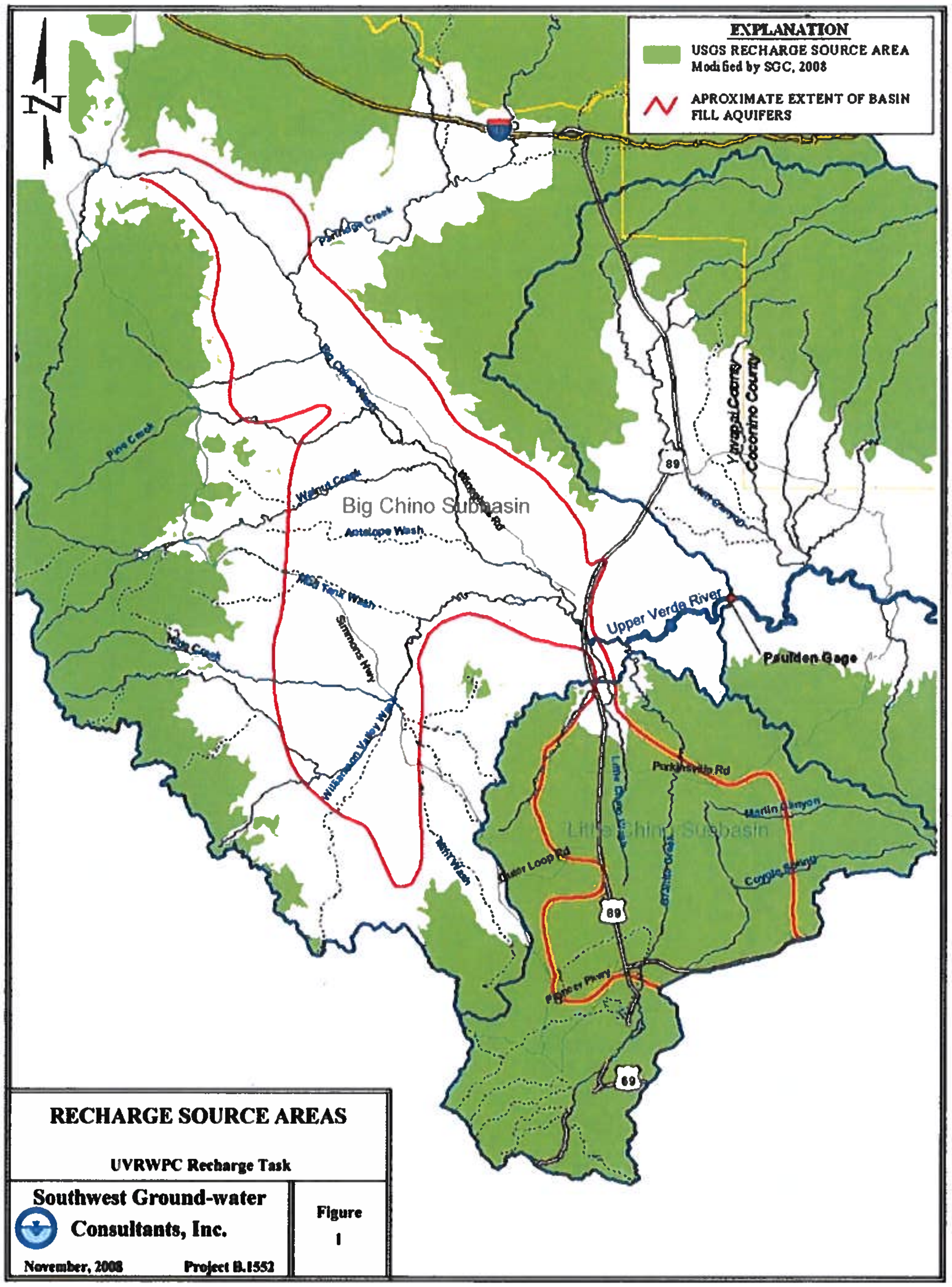
  Review land development policies and ordnances. Develop "model policies/ordnances" to reduce evaporation and promote infiltration/recharge, particularly in the areas identified as significant natural recharge areas in this report.

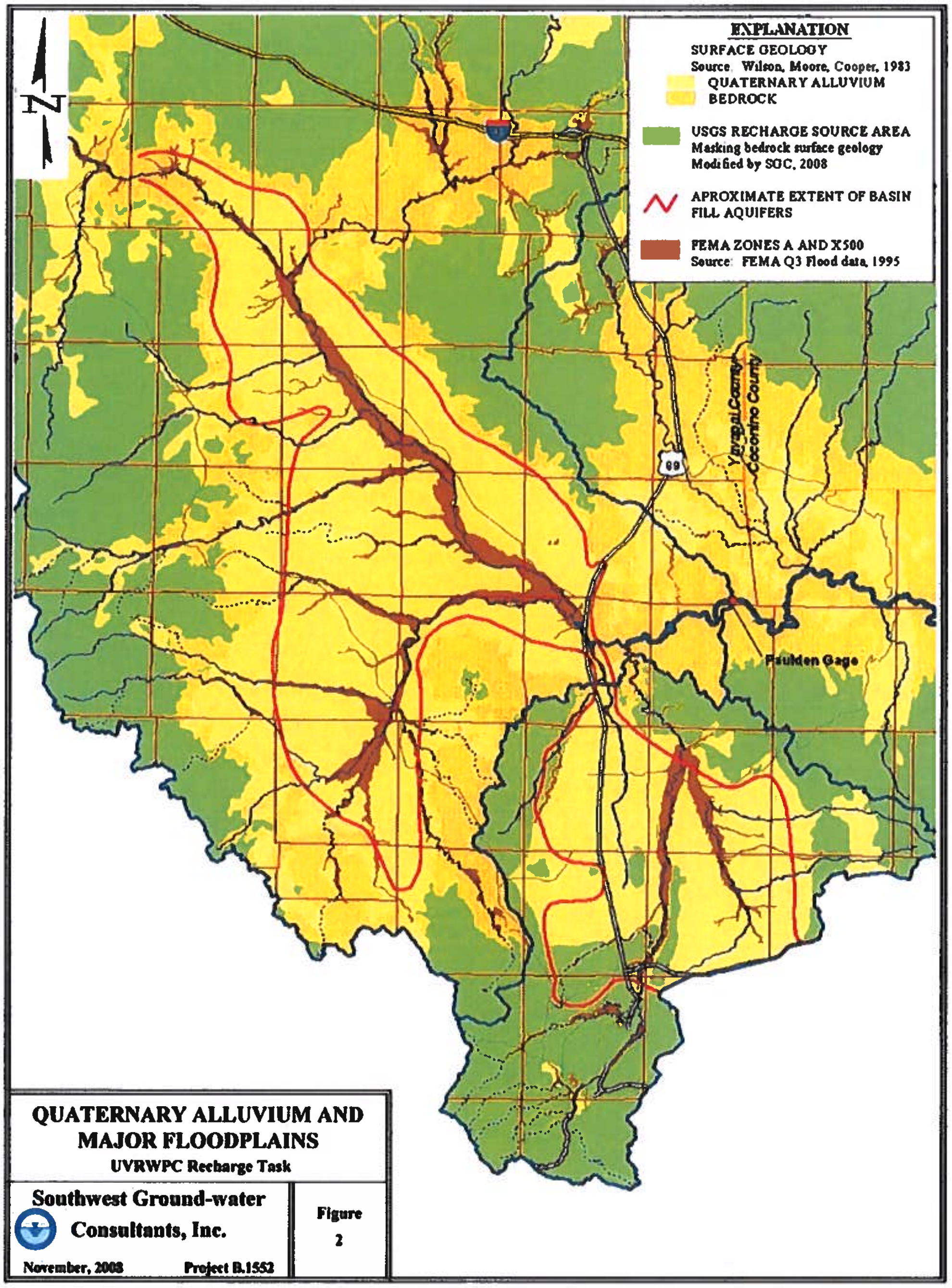
Artificial Recharge

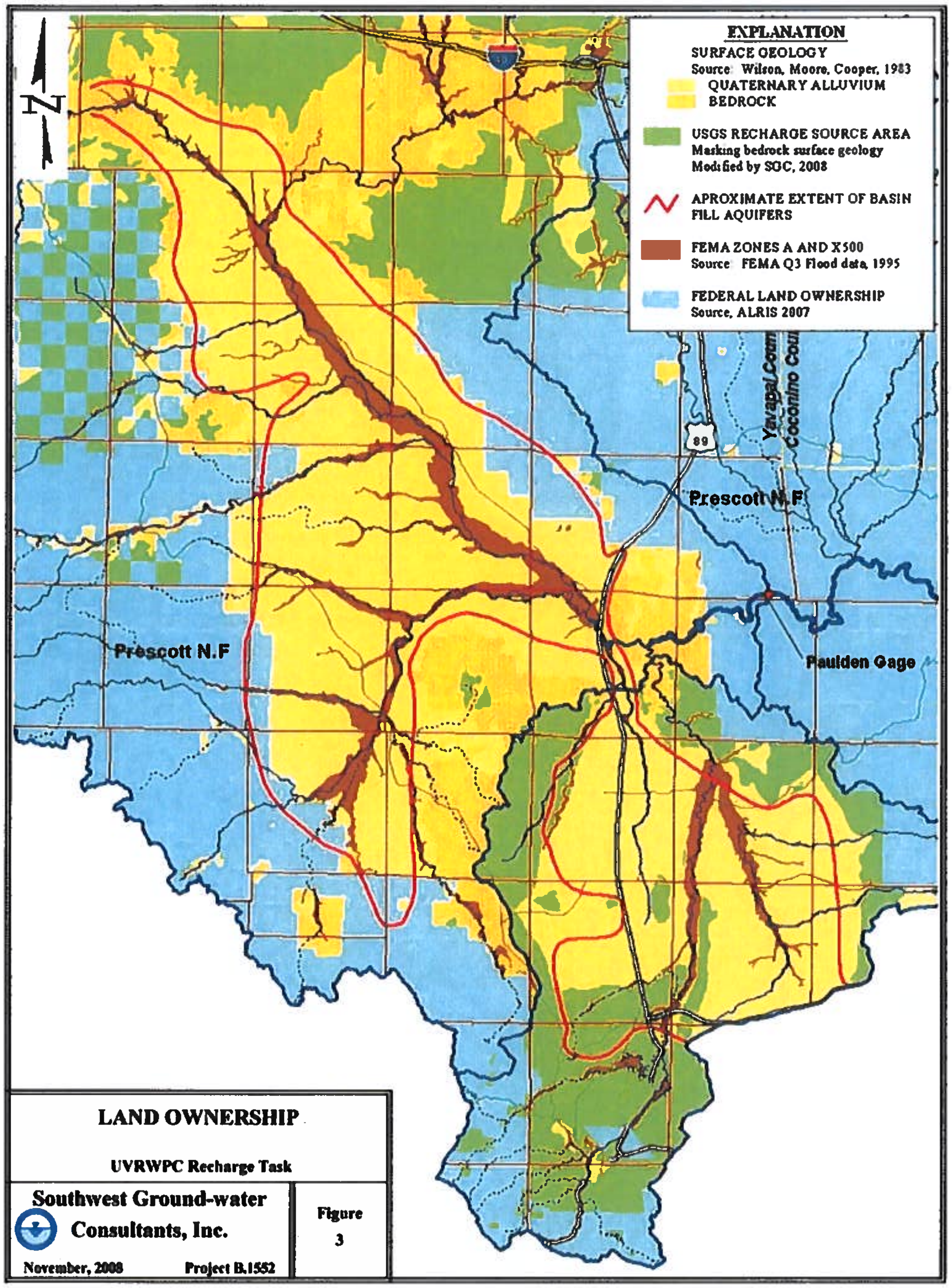
- Develop an inventory of water available for recharge. Define potential volumes, timing, quality and legal issues. Sources should include, but not be limited to:
  - Effluent
  - Surface water runoff
  - Imported water
  - Historically Irrigated Acreage (HIA) ground water
- Review current and proposed wastewater water treatment plant discharge plans and identify:
  - Plant ownership, location and volume of effluent
  - Treatment levels
  - Planned reuse and recharge
  - the potential volume of effluent available from unsewered areas and their potential for recharge
  - Develop position/policy statement on the collection, treatment and recharge of effluent in the Upper Verde River watershed.
- Identify options for the capture and recharge of surface water. Assess:
  - appropriated and unappropriated waters
  - legal issues
  - existing capture/control facilities (dams, canals, pipelines)
  - additional facility requirements
  - cost/benefits
- Review sources of water for importation
  - Ongoing studies
  - Long-term future sources (brainstorming)
  - Cost/benefits
- Use of HIA water for recharge
  - location and volume of HIA water
  - location and purpose of recharge (offset drawdown, safe yield, support baseflow)
  - cost/benefits

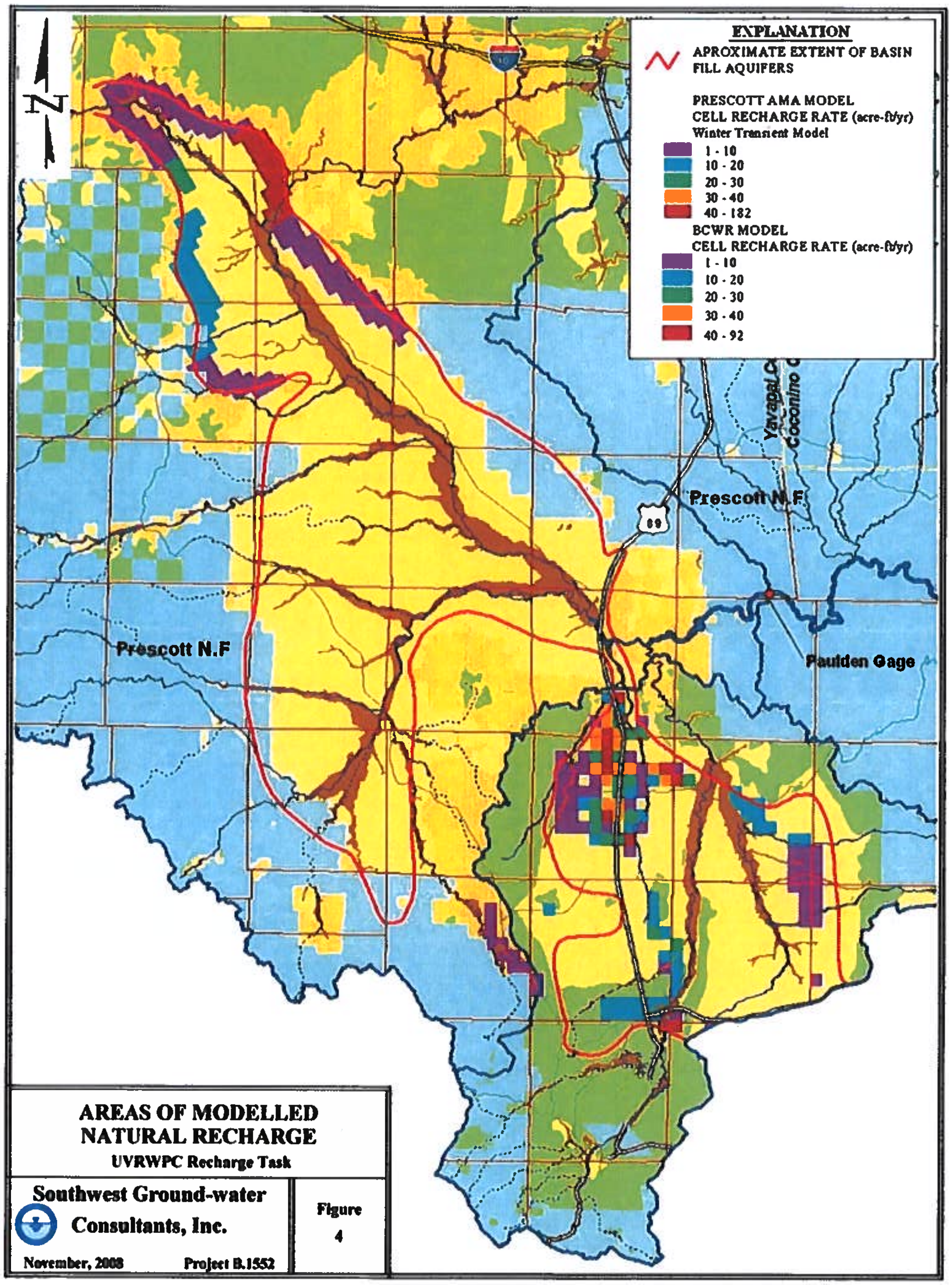
* * *

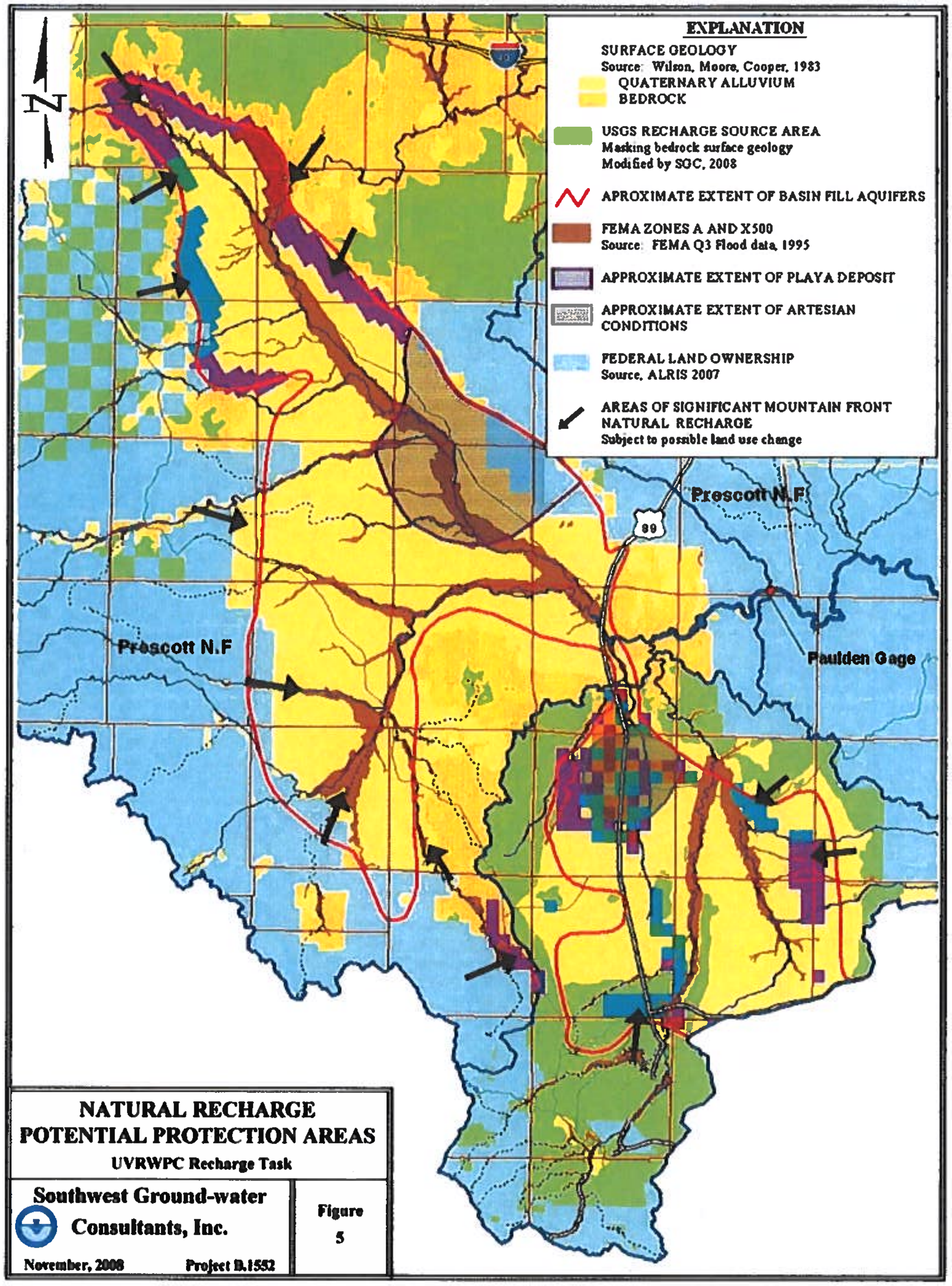
IN POCKET – CD with GIS files


EXPLANATION
USGS RECHARGE SOURCE AREA
Modified by SGC, 2008
APROXIMATE EXTENT OF BASIN FILL AQUIFERS
N
Big Chino Subbasin
Little Chino Subbasin
Upper Verde River
Pauldon Gage
Partridge Creek
Big Chino Wash
Pine Creek
Walnut Creek
Antelope Wash
Williamson Valley Wash
Simmons Hwy
Parkinsville Rd
Outer Loop Rd
Pioneer Pkwy
Yavapai County
Coconino County
89
RECHARGE SOURCE AREAS
UVRWPC Recharge Task
Southwest Ground-water Consultants, Inc.
November, 2008
Project B.1552
Figure 1


EXPLANATION
SURFACE GEOLOGY
Source: Wilson, Moore, Cooper, 1983
QUATERNARY ALLUVIUM
BEDROCK
USGS RECHARGE SOURCE AREA
Masking bedrock surface geology
Modified by SGC, 2008
APROXIMATE EXTENT OF BASIN FILL AQUIFERS
FEMA ZONES A AND X500
Source: FEMA Q3 Flood data, 1995
N
Yavapai County
Coconino County
89
Paulden Gage
QUATERNARY ALLUVIUM AND MAJOR FLOODPLAINS
UVRWPC Recharge Task
Southwest Ground-water Consultants, Inc.
November, 2008
Project B.1552
Figure 2


EXPLANATION
SURFACE GEOLOGY
Source: Wilson, Moore, Cooper, 1983
QUATERNARY ALLUVIUM
BEDROCK
USGS RECHARGE SOURCE AREA
Masking bedrock surface geology
Modified by SGC, 2008
APROXIMATE EXTENT OF BASIN FILL AQUIFERS
FEMA ZONES A AND X500
Source: FEMA Q3 Flood data, 1995
FEDERAL LAND OWNERSHIP
Source, ALRIS 2007
N
89
Prescott N.F
Prescott N.F
Paulden Gage
LAND OWNERSHIP
UVRWPC Recharge Task
Southwest Ground-water Consultants, Inc.
November, 2008
Project B.1552
Figure 3


EXPLANATION
APROXIMATE EXTENT OF BASIN FILL AQUIFERS
PRESCOTT AMA MODEL
CELL RECHARGE RATE (acre-ft/yr)
Winter Transient Model
1 - 10
10 - 20
20 - 30
30 - 40
40 - 182
BCWR MODEL
CELL RECHARGE RATE (acre-ft/yr)
1 - 10
10 - 20
20 - 30
30 - 40
40 - 92
N
Yavapai Co
Coconino Co
Prescott N.F
89
Prescott N.F
Paulden Gage
AREAS OF MODELLED NATURAL RECHARGE
UVRWPC Recharge Task
Southwest Ground-water Consultants, Inc.
November, 2008
Project B.1552
Figure 4


EXPLANATION
SURFACE GEOLOGY
Source: Wilson, Moore, Cooper, 1983
QUATERNARY ALLUVIUM
BEDROCK
USGS RECHARGE SOURCE AREA
Masking bedrock surface geology
Modified by SGC, 2008
APROXIMATE EXTENT OF BASIN FILL AQUIFERS
FEMA ZONES A AND X500
Source: FEMA Q3 Flood data, 1995
APPROXIMATE EXTENT OF PLAYA DEPOSIT
APPROXIMATE EXTENT OF ARTESIAN CONDITIONS
FEDERAL LAND OWNERSHIP
Source, ALRIS 2007
AREAS OF SIGNIFICANT MOUNTAIN FRONT NATURAL RECHARGE
Subject to possible land use change
N
Prescott N.F
Prescott N.F
Paulden Gage
89
NATURAL RECHARGE
POTENTIAL PROTECTION AREAS
UVRWPC Recharge Task
Southwest Ground-water
Consultants, Inc.
Figure
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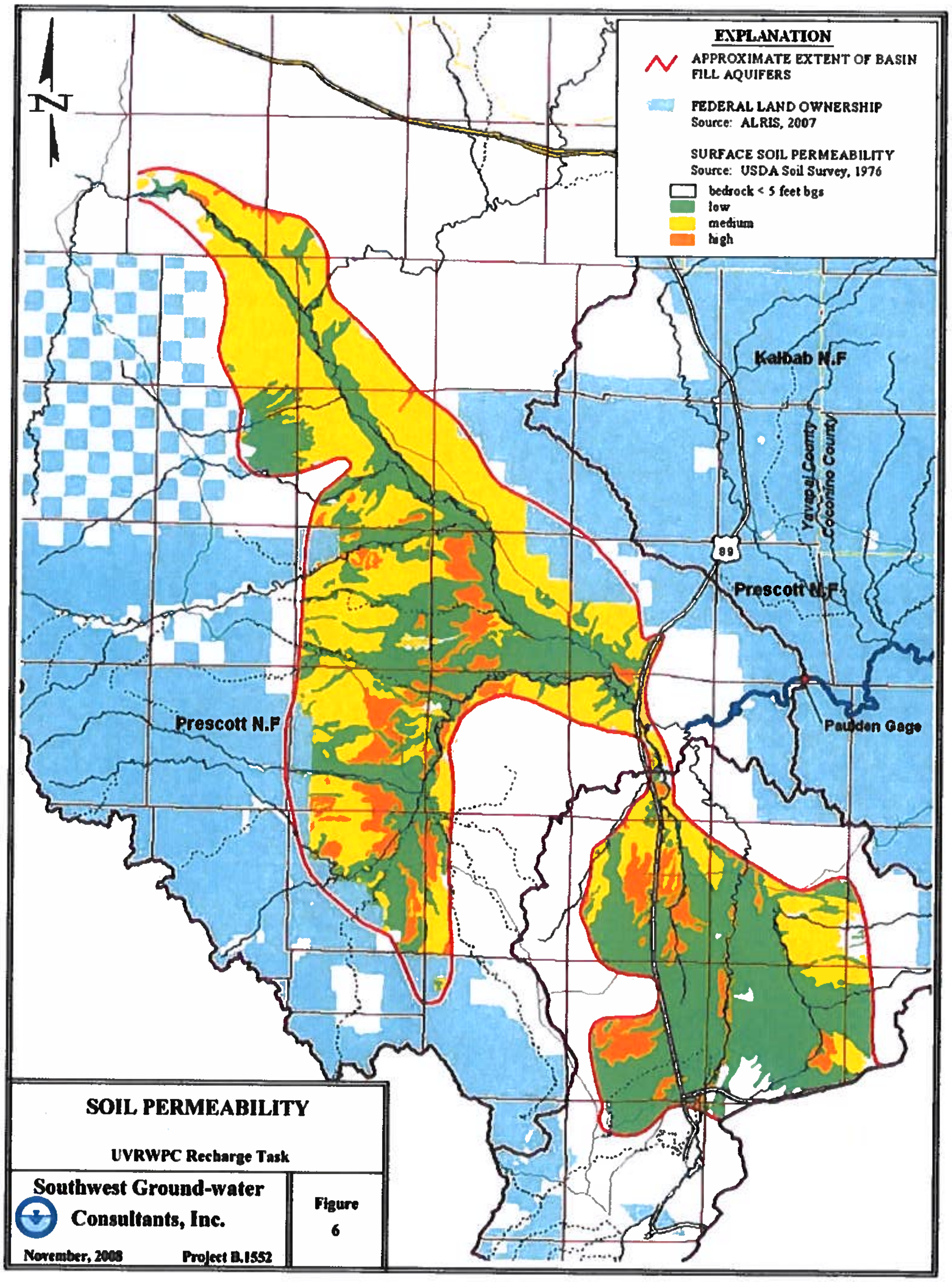
EXPLANATION
APPROXIMATE EXTENT OF BASIN FILL AQUIFERS
FEDERAL LAND OWNERSHIP
Source: ALRIS, 2007
SURFACE SOIL PERMEABILITY
Source: USDA Soil Survey, 1976
bedrock < 5 feet bgs
low
medium
high
N
Kaibab N.F
Yavapai County
Coconino County
89
Prescott N.F
Prescott N.F
Paulden Gage
SOIL PERMEABILITY
UVRWPC Recharge Task
Southwest Ground-water Consultants, Inc.
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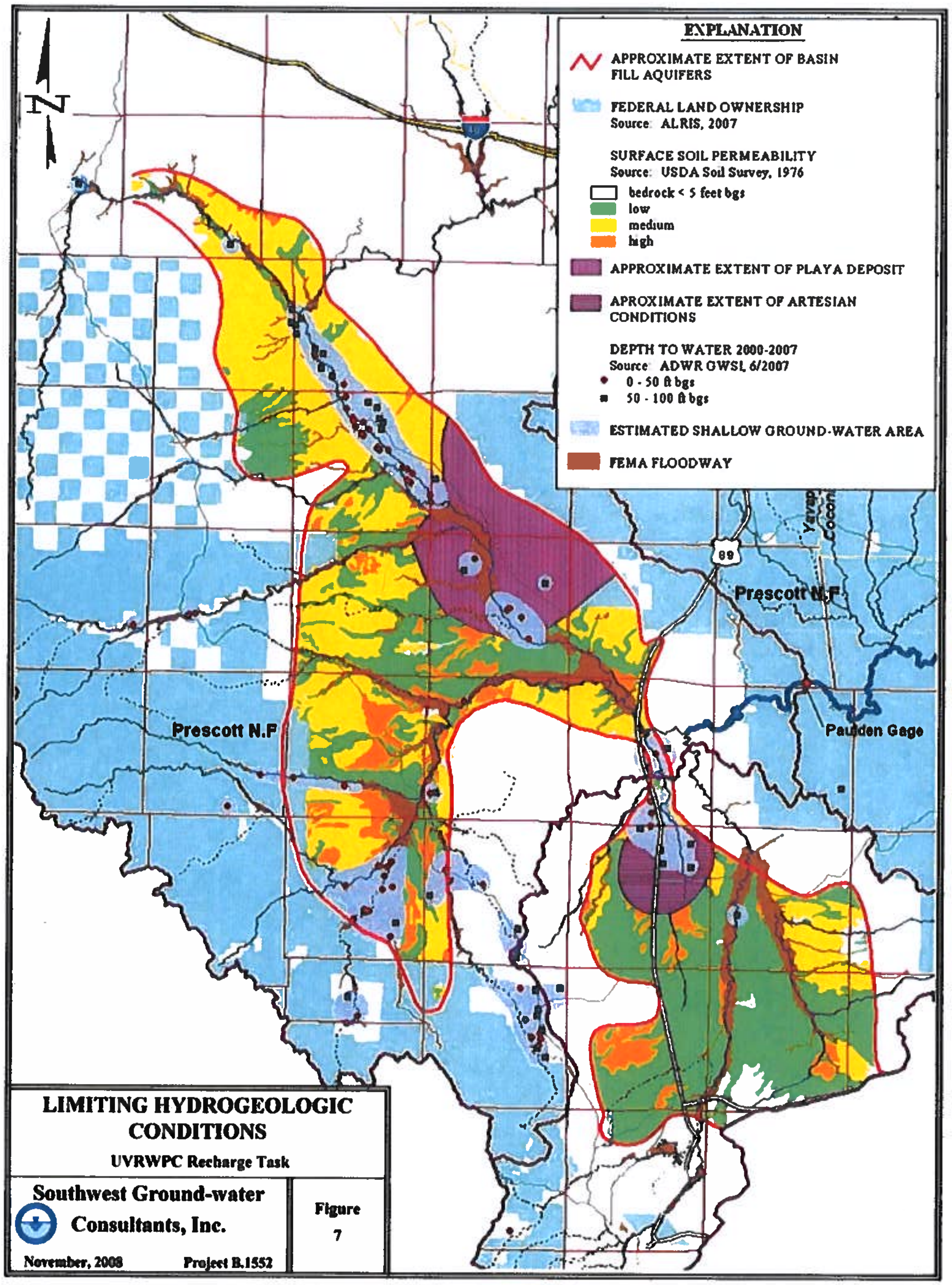
Figure 6


EXPLANATION
APPROXIMATE EXTENT OF BASIN FILL AQUIFERS
FEDERAL LAND OWNERSHIP
Source: ALRIS, 2007
SURFACE SOIL PERMEABILITY
Source: USDA Soil Survey, 1976
bedrock < 5 feet bgs
low
medium
high
APPROXIMATE EXTENT OF PLAYA DEPOSIT
APROXIMATE EXTENT OF ARTESIAN CONDITIONS
DEPTH TO WATER 2000-2007
Source: ADWR GWSI, 6/2007
0 - 50 ft bgs
50 - 100 ft bgs
ESTIMATED SHALLOW GROUND-WATER AREA
FEMA FLOODWAY
N
Prescott N.F
Prescott N.F
Paulden Gage
89
LIMITING HYDROGEOLOGIC CONDITIONS
UVRWPC Recharge Task
Southwest Ground-water Consultants, Inc.
Figure 7
November, 2008
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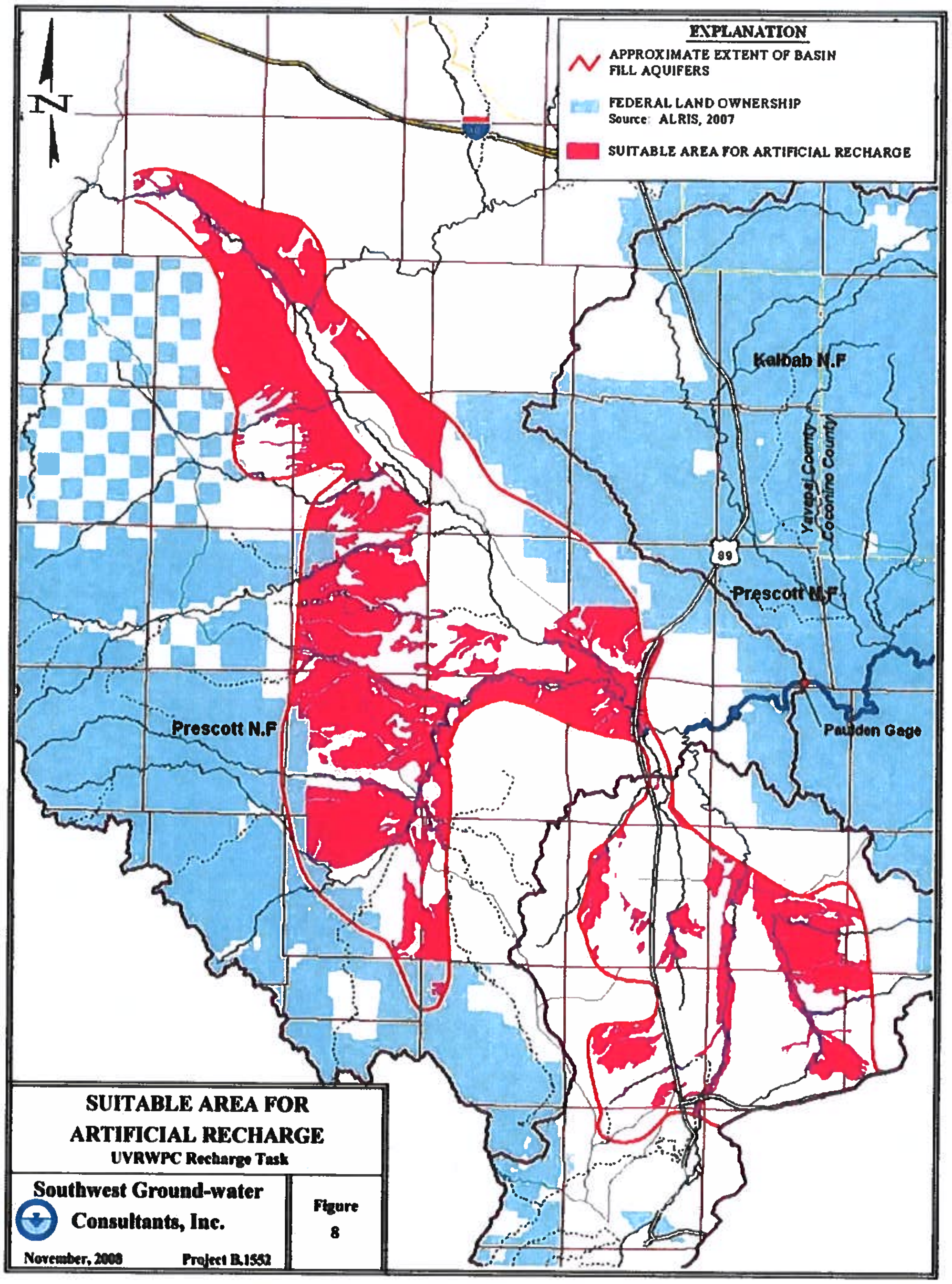

EXPLANATION
APPROXIMATE EXTENT OF BASIN FILL AQUIFERS
FEDERAL LAND OWNERSHIP
Source: ALRIS, 2007
SUITABLE AREA FOR ARTIFICIAL RECHARGE
N
Kaibab N.F
Yavapai County
Coconino County
89
Prescott N.F
Prescott N.F
Paulden Gage
SUITABLE AREA FOR
ARTIFICIAL RECHARGE
UVRWPC Recharge Task
Southwest Ground-water
Consultants, Inc.
November, 2008
Project B.1552
Figure
8

July 7, 2008

REPORT

Preliminary Assessment of Recharge Feasibility for Site Near Paulden

Yavapai County, Arizona

Prepared for:
Town of Chino Valley

Prepared by:
Errol L. Montgomery & Associates, Inc.

WATER RESOURCE CONSULTANTS

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July 7, 2008
REPORT

PRELIMINARY ASSESSMENT OF RECHARGE FEASIBILITY FOR SITE NEAR PAULDEN YAVAPAI COUNTY, ARIZONA

Prepared for:

TOWN OF CHINO VALLEY

ERROL L. MONTGOMERY & ASSOCIATES, INC.
WATER RESOURCE CONSULTANTS

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REGISTERED GEOLOGIST
CERTIFICATE NO.
19193
MARK M.
CROSS
Date Signed 7/7/08
ARIZONA U.S.A.
Expires 6/30/2011

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ERROL L. MONTGOMERY & ASSOCIATES, INC.

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ERROL L. MONTGOMERY & ASSOCIATES, INC.

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ERROL L. MONTGOMERY & ASSOCIATES, INC.

July 7, 2008
REPORT

PRELIMINARY ASSESSMENT OF RECHARGE FEASIBILITY FOR SITE NEAR PAULDEN YAVAPAI COUNTY, ARIZONA

Prepared for:

TOWN OF CHINO VALLEY

INTRODUCTION

In accordance with a request from the Town of Chino Valley (the Town), Errol L. Montgomery and Associates, Inc. (M&A) has prepared this hydrogeologic report to provide results of a preliminary assessment of recharge feasibility for a parcel of land encompassing approximately 75 acres in the northwest quadrant of Section 4 of Township 17 North, Range 2 West, in Paulden, Arizona. A location map for this parcel is shown on **Figure 1** and an aerial photograph for the same area is shown on **Figure 2**. The parcel is located in the southeast part of the Big Chino sub-basin and lies outside the Prescott Active Management Area, as defined by the Arizona Department of Water Resources (ADWR). This preliminary or "Phase 1" feasibility assessment was conducted as part of due diligence requirements associated with purchase of the parcel for a recharge project that may be developed by the Town for storage of treated effluent or imported water in the regional aquifer. It is our understanding that the Town's goal is to develop sufficient recharge capacity at this parcel to store 4,000 to 8,000 acre-feet per year (AF/yr), if possible, and eventually to increase recharge capacity at this site and/or additional sites in the Big Chino sub-basin for storage of as much as 20,000 AF/yr.

The purchase agreement for this proposed recharge site entitles a mining company to mine sand and gravel in the upper 20 to 30 feet of the vadose zone over much of the parcel. The resultant pit would become the basis for a recharge facility consisting of closely-spaced surface infiltration basins separated by earthen berms, although shallow vadose zone injection wells could also be installed to increase recharge rates if needed.

This Phase 1 assessment is based chiefly on review and evaluation of available data for hydrogeologic conditions and land use in the vicinity of the proposed recharge site, with limited site-specific data. Therefore, the principal objective of this assessment is to: 1) identify potential fatal flaws for recharge operations at the site; 2) provide preliminary estimates of recharge capacity for the site to the extent supported by available data; and 3) identify key issues and data needs to better evaluate recharge feasibility and capacity. Results from Phase 1 will also be used to determine the requirements and scope of work for potential future Phase 2 technical feasibility investigations at the site.

A well inventory for the vicinity of the proposed recharge site was prepared by compiling well records from the ADWR "55", "35", and Groundwater Site Inventory (GWSI) databases. This well inventory is given in **Table 1**, and includes well locations, well construction details, historic groundwater levels, and well uses. Locations for wells are shown on **Figure 1**.

HYDROGEOLOGIC CONDITIONS

Available data for hydrogeologic conditions in the vicinity of the proposed recharge site was obtained from published reports and unpublished data from the U.S. Geological Survey (USGS), Arizona Geological Survey, and ADWR. M&A recently prepared a hydrogeologic report in support of an application for Analysis of Assured Water Supply for the Town (Assured Water Supply Report) summarizing hydrogeologic conditions for a large area surrounding Paulden (M&A, 2007), which includes the proposed recharge site. Much of the regional hydrogeologic information in the present report was taken from the 2007 report.

REGIONAL HYDROGEOLOGY

The Big Chino sub-basin is located in the Basin and Range Physiographic Province of Arizona and comprises about 1,850 square miles in the Big Chino Valley. The Big Chino sub-basin is a northwest to southeast trending valley that is drained principally by Big Chino Wash. The proposed recharge site is in the southeast part of the sub-basin, on the west side of the town of Paulden.

The Big Chino sub-basin is bounded on the northeast by Big Chino Fault and Big Black Mesa and to the southwest by the Juniper and Santa Maria Mountains. The sub-basin comprises a fault-block graben that overlays gently-dipping Paleozoic rocks. The graben is filled with basin-fill deposits, including alternating beds of alluvial sediments and basalt flows (Blasch and others, 2006). The graben is approximately 6 miles wide near the southern portion of the valley, near the town of Paulden.

The geologic units, from youngest to oldest, include basin-fill deposits of Quaternary and Tertiary sedimentary units, Tertiary basalt, Tertiary lati-andesite intrusive and extrusive volcanic rocks; early Paleozoic sedimentary units; and Precambrian bedrock. The upper basin-fill deposits includes unconsolidated coarse- to fine-grained sediments, sandstone, siltstone, and conglomerates interbedded with basalt and lati-andesite volcanic flows. The early Paleozoic units include the Redwall Limestone, the Martin Formation, the Bright Angel Shale, and the Tapeats Sandstone.

The Big Chino sub-basin is deepest in the center and thins to the southeast. The underlying Paleozoic sedimentary units in the area are at least 400 feet thick. The overlying basin-fill deposits are thickest in the center of the basin along the Big Chino Fault where geophysical studies indicate thicknesses up to 2,500 feet (Langenheim, 2006). Based on inspection of Sections A-A' and B-B' (Figure 18 in Blasch and others, 2006), in the vicinity of the recharge site in the southeast part of the Big Chino sub-basin, the upper part of the basin-fill deposits comprises (unconsolidated) Quaternary and Tertiary sediments approximately 100 to 200 feet thick. These alluvial sediments are underlain by a basalt-flow unit approximately 200 feet thick, which is underlain by approximately 300 to 400 feet of Tertiary sedimentary deposits, potentially including unconsolidated alluvial sediments, siltstones, sandstones, and minor conglomerate. Total thickness of the basin-fill deposits in the vicinity of the recharge site is estimated to be more than 600 feet and perhaps up to 800 feet.

The principal productive water-bearing units (aquifer) in the southern portion of Big Chino sub-basin comprise the basin-fill deposits, including the Quaternary and Tertiary alluvium and Tertiary basalt flows, and to a lesser degree, the underlying consolidated early Paleozoic sedimentary units (Blasch and others, 2006). Paleozoic limestones are known to yield groundwater to wells north of Paulden. However, most groundwater wells in the Big Chino sub-basin draw water from the basin-fill deposits (including the highly fractured basalt flows). The Tertiary lati-andesite intrusive and extrusive volcanic rocks are considered barriers to groundwater flow (Schwalen, 1967; Blasch and others, 2006). The Precambrian rock comprises the hydrologic basement beneath the valley floor and is considered to be a barrier to groundwater flow.

AQUIFER CHARACTERISTICS

As indicated above, the principal aquifer in the southeast part of the Big Chino sub-basin, including the vicinity of the proposed recharge site, is the basin-fill deposits, including the Quaternary and Tertiary alluvium and the Tertiary basalt flows. Where saturated, the alluvium comprises an unconfined aquifer. The Tertiary basalt is reported to be unconfined in most locations, but confined in some locations (Blasch and others, 2006).

Groundwater Occurrence and Movement

There has been little groundwater development in the Big Chino sub-basin. Groundwater withdrawals in the Big Chino sub-basin from 1950 to 1966 were 22,000 acre-feet, were about 11,000 acre-feet per year from 1967 to 1977, and then decreased substantially (Schwab, 1995). Hydrographs for wells in the area are shown on Figure 4 of the Assured Water Supply Report (M&A, 2007) and indicate that average rate of water level decline was less than 0.5 feet per year.

Groundwater in the Big Chino sub-basin generally flows from northwest to southeast, parallel to the direction of surface water flow. For reference, groundwater level altitudes and contours in the Big Chino sub-basin for 1992 (taken from Schwab, 1995) are reproduced on Figure 5 of the Assured Water Supply Report (M&A, 2007). Inspection of this figure indicates that the hydraulic gradient in the southeast part of the sub-basin, including the proposed recharge site, was small (no groundwater contours are even shown for this area). Because only small amounts of groundwater have been withdrawn from the sub-basin in recent years, present groundwater level contours and direction of groundwater flow are expected to be very similar to those that occurred prior to development in the sub-basin. Evaluation of limited available data for groundwater level measurements for 1999 and 2004 (from the GWSI database) supports the general relation that hydraulic gradients in the vicinity of the recharge site were still small in these more recent years.

Recent groundwater level data are not available for the proposed recharge site, but limited data are available for several wells in the vicinity of the site. The most recent groundwater level measurements were generally obtained in 2004, although a depth to water of 104 feet was measured in March 2007 at well (B-17-02)04dbc [DRM-2], located about 1/3 mile southeast from the site. Based on inspection and interpolation of the available data for depth to groundwater level and groundwater level altitude in the vicinity of the recharge site, current depth to groundwater level at the site is estimated to be between 100 and 110 feet below land surface (bls).

Aquifer Hydraulic Properties

Limited data are available for aquifer hydraulic properties for the southeast part of the Big Chino sub-basin, including the vicinity of the proposed recharge site. Aquifer hydraulic properties include transmissivity, hydraulic conductivity, and specific yield or storage coefficient and are important for evaluating recharge feasibility because they control the capacity of the aquifer to accept, store, and transmit water.

Pumping test information is available for several wells in the Big Chino sub-basin, including results of pumping tests conducted by M&A in 2006; these results are all summarized in the Assured Water Supply Report (M&A, 2007). Aquifer transmissivities reported for two wells near the potential recharge site ranged from 2,700,000 to

3,600,000 gallons per day per foot width of aquifer (gpd/ft) for well (B-17-02)04cda and from 1,400,000 to 1,600,000 gpd/ft for well (B-17-02)04 (Blasch and others, 2006). Storage coefficients reported for the basin-fill deposits aquifer (combined alluvium and basalt flows) range from 0.032 to 0.545 (Blasch and others, 2006). A 48-hour pumping test was conducted by M&A in 2006 at each of two wells located 2 miles west and 1.5 miles northwest from the proposed recharge site: (B-18-02)31ccc [Larson well] and (B-18-02)32bbb [Scott well]. Based on available well construction data, these two wells are completed in the upper basin-fill deposits aquifer. Computed aquifer transmissivity was about 2,200,000 gpd/ft for the Larson well and about 1,700,000 gpd/ft for the Scott well; these results are generally similar to the transmissivities reported for wells (B-17-02)04cda and (B-17-02)04 (Blasch and others 2006). These large transmissivity values determined from pumping tests at wells located relatively close to the proposed recharge site indicate that the upper basin-fill deposits aquifer at the site is also likely to have a relatively large transmissivity, which would promote movement of water away from the recharge site during recharge operations and reduce the height of groundwater mounding.

LITHOLOGIC CONDITIONS NEAR THE RECHARGE SITE

Available data for lithologic conditions in the immediate vicinity of the proposed recharge site consist chiefly of drillers' logs obtained through the ADWR "55" database; a few logs that were not in the database were obtained from consultants' reports. Drillers' logs available for wells within an approximate 1-mile radius of the site are given in **Appendix A**. Most of the drillers' logs are very general and of limited reliability, especially regarding relative abundance of sand, silt, and clay in the alluvial sediments (e.g. "0 to 130 feet consists of clay and gravel"). A few logs have slightly more detailed descriptions and/or include numerous delineated intervals, which was assumed to indicate a more reliable representation of lithology. The most complete and descriptive log available for the vicinity of the proposed recharge site is for well (B-17-02)04dbc [DRM-2]; this well is located about 1/3-mile southeast from the site. In addition, similarity of general lithologic layers or trends observed in the logs of "limited reliability" provides some basis for evaluating the general stratigraphy of the subsurface profile. However, to obtain reliable estimates of potential recharge capacity of this site, more detailed lithologic, physical, and hydraulic data for the saturated zone and vadose zone strata at and near the site would be required.

Based on review of available drillers' logs for wells within approximately 1 mile of the proposed recharge site (**Appendix A**), and in the absence of appropriate site-specific investigations, the following lithologic characteristics of the upper basin-fill deposits in the vicinity of the recharge site can be ascertained:

1. Generally unconsolidated alluvial sediments occur in the upper part of the vadose zone and are underlain by basalt flows; the thickness of the upper interval of alluvial sediments ranges from a few feet at the east boundary of Section 4 (about 3/4-mile east from the site) to more than 250 feet about 1 mile west from the site. Based on logs for two wells that have registered locations within the 75-acre recharge site (4bbc and 4bca), top of the basalt occurs at a depth of 145 to 150 feet at the site.

2. As stated previously, thickness of the basalt-flow unit at the south end of the Big Chino sub-basin is approximately 200 feet. Very few wells in the vicinity of the proposed recharge site (for which drillers' logs are available) fully penetrate the interval of basalt flows. Based on the "more reliable" log for well DRM-2, located about 1/3-mile southeast from the site and drilled to a depth of 600 feet, basalt flows occur in the depth interval from 130 to 325 feet bls and are underlain by more alluvial sediments. Many of the drillers' logs indicate that the basalt flows are fractured.

3. Based on selected drillers' logs that attempt to delineate intervals of differing sediment type in the upper alluvim, lithologic and stratigraphic conditions of the vadose zone in the vicinity of the recharge site can be summarized as consisting of: relatively medium- to coarse-grained sediments from land surface to depths ranging from about 20 to 40 feet bls, underlain by fine-grained sediments to the top of basalt. The term "coarse-grained" refers to the descriptions of "sand and/or gravel" in the drillers' logs. The term "medium-grained" is used in this summary to refer to the sediment descriptions of "clayey sand" and "conglomerate". The term "fine-grained" is used in this summary to refer to the sediment descriptions of "clay", "sandy silty clay", and "sandy clay". It is important to note that none of these terms can be taken too literally; e.g. the term "clay" is often used by drillers to refer to anything that isn't obviously sand and gravel, and the term "conglomerate" as used by drillers could mean almost anything but likely refers to sediments that are heterogeneous and relatively consolidated.

4. Based on the ADWR "55" database, two wells are indicated to be located within the 75-acre recharge site, well (B-17-02)04bbc and well (B-17-02)04bca. The drillers' logs for these two wells **(Appendix A)** are of limited detail and reliability, but indicate the following (summarized):

   - well (B-17-02)04bbc: sand and/or gravel to a depth of 23 feet; conglomerate from 23 to 40 feet; sand/clay from 40 to 47 feet; clay from 47 to 60 feet; sand/clay from 60 to 78 feet; clay from 78 to 146 feet; and "malapai" from 146 to 250 feet.

   - well (B-17-02)04bca: sand and/or gravel (with boulders) to a depth of 29 feet; clayish conglomerate from 29 to 147 feet; and "malapai" from 147 to 177 feet.

5. Based again on the "more reliable" log for well DRM-2, located about 1/3-mile southeast from the site, the unconsolidated sediments overlying the basalt-flow unit (at a depth of 130 feet) were described as:

- silty sandy clay to a depth of 5 feet; clayey sand from 5 to 20 feet; silty or sandy gravelly clay from 20 to 85 feet; and clay from 85 to 130 feet.

6. Due to the commencement of sand and gravel mining at the recharge site, a pit has been excavated in the southwest corner of the site; the pit wall provides a soil profile to a depth of approximately 22 feet (as of June 2008). Based on a lithologic description of the exposed soil profile (courtesy of Mark Holmes, Town of Chino Valley), the upper 10 feet of the soil profile consists of silty sand and sandy silt and is underlain to the base of the pit by generally coarse-grained sediments, including sand, gravelly sand, and sandy gravel strata with generally minor silt and/or clay content and sparse lenses of silty sand/sandy silt; the actual profile description and selected photos are provided on **Figures A-1, A-2, and A-3 of Appendix A**. According to the sand and gravel operator, the floor of the pit (depth of 22 feet) consists of "hard sandy silty clay that is hard to penetrate", and this material extends to the maximum depth of their exploration trenching of 30 to 35 feet with some interbeds of sandy/gravelly sediments. However, the sand and gravel operator also indicated that these underlying fine-grained sediments ("clay") were very similar to the fine-grained sediments encountered in the upper 10 feet of the soil profile, which actually consisted of silty sand and sandy silt. Therefore, it is likely that the fine-grained sediments underlying the pit floor are not as clayey as indicated by the operator's brief description.

7. The depth of occurrence of fine-grained sediments in the sand and gravel pit of about 22 feet is consistent with the general range of depths for depth to the top of the fine-grained intervals indicated in (most of) the drillers logs for wells in the vicinity of the recharge site. Although most of the drillers' logs are of limited reliability, the logs for wells nearest the site appear to be consistent in indicating a generally fine-grained zone that begins at a depth ranging from about 20 to 40 feet and extends to the top of basalt at depths ranging from about 110 to 150 feet. Therefore, it is likely that the fine-grained sediments observed at a

depth of about 22 feet in the sand and gravel pit at the site represent the top of a thick interval of generally fine-grained sediments. However, as explained in previous bullets 3 and 6, the terms used to represent this fine-grained interval (e.g. clay or sandy clay, etc.) may not be accurate when interpreted literally and the actual sediment texture could be (probably is) more sandy or at least not as continuous (includes coarser-grained lenses) than is inferred by the drillers' brief description. In addition, even if the terms are reasonably accurate/literal, the physical and hydraulic properties of these fine-grained sediments are not known, which makes it very difficult to quantify infiltration capacity.

EVALUATION OF RECHARGE FEASIBILITY

Feasibility for recharge operations depends on: 1) the Town's recharge goals, including the volume of water that needs to be stored and the time over which storage needs to be accomplished; 2) hydrogeologic conditions at the site, including infiltration capacity of near-surface sediments, lithologic and stratigraphic conditions of the vadose zone and aquifer, and chemical quality of source water and receiving groundwater; 3) rates and volumes of recharge at other nearby recharge site(s); and 4) factors not related to hydrogeologic conditions such as proximity to the source water supply, nearby land uses and potential contamination sources, nearby water uses, regulatory constraints, and construction and operation costs. The present Phase 1 investigation provides a preliminary evaluation of most of these aspects based on available information, but a more comprehensive study and site-specific investigations would be required to accurately address all the relevant factors.

Artificial groundwater recharge can be conducted by surface infiltration or by injection into the vadose zone and/or saturated zone (aquifer) using wells. If the source water would be treated effluent (or otherwise of poor quality), recharge by direct injection into the aquifer may require additional water treatment due to more stringent regulatory constraints, and might also be subject to (possibly insurmountable) public perception concerns. Conversely, if the recharge source water would comprise good quality imported groundwater, direct injection may be the most cost effective and technically feasible option, or at least an important component of the recharge facility. However, in this event, injection wells could be located in very small available areas and spread out if need be, and there would be no need for a recharge facility within an excavated sand and gravel pit. Therefore, for the purposes of this Phase 1 assessment for the 75-acre parcel, direct injection is not being considered in evaluating recharge feasibility.

Recharge using vadose zone injection wells has fewer regulatory constraints than injection directly into the aquifer and may have technical advantages over surface infiltration if the vadose zone stratigraphy consists of substantial fine-grained strata in the near-surface zone with permeable coarse-grained strata deeper in the subsurface; the limited available lithologic data for the proposed recharge site does not indicate this vadose zone stratigraphy. In general, assuming sufficient land area is available, surface infiltration basins tend to be the most technically and economically feasible option due to larger overall loading rates and the relative ease of rehabilitating a basin if/when surface plugging reduces infiltration rates substantially. For these reasons, and because the site is being excavated for mining of sand and gravel with associated construction of basins (which eliminates/reduces costs associated with basins), the design for a future recharge facility is likely to comprise surface infiltration basins and this is the primary focus of the feasibility assessment.

HYDROGEOLOGIC FEASIBILITY

Summary of Technical Considerations

Based on the available lithologic data for the vicinity of the proposed recharge site and the resultant characterization/interpretation of subsurface lithologic and stratigraphic conditions at the site, described previously, technical considerations and preliminary conclusions for assessing recharge feasibility are summarized as follows:

1. The vadose zone below a depth of approximately 30 feet likely consists of generally or predominantly "fine-grained" sediments.

2. Site-specific data for more detailed lithologic and hydraulic characterization of the subsurface sediments underlying the floor of the (potential) recharge basins

could not be obtained as part of the Phase 1 investigations. Therefore, estimates of infiltration rates (for surface basins), injection rates (for vadose zone wells), and overall recharge capacity for the site cannot be prepared with a high level of confidence.

3. Assuming that surface infiltration basins would be constructed at the bottom of the pit being excavated for sand and gravel mining, and that the general pit depth will be about 22 feet, infiltration rates will be controlled by the underlying fine-grained sediments and could potentially be small. Although the fine-grained sediments in the first few feet underlying the basin floor may not be as clayey and poorly permeable as generally inferred by the drillers' logs and description provided by the sand and gravel operator, the deeper fine-grained sediments could be more clayey and less permeable, and therefore, more impeding to infiltration.

4. The same consideration regarding infiltration capacity of surface infiltration basins in the previous bullet also applies to recharge operations using vadose zone injection wells. Injection wells that are screened in relatively fine-grained sediments would have small infiltration rates with an associated small recharge capacity per well. Therefore, assuming that thick and/or continuous coarse-grained sediment strata do not occur deeper in the vadose zone, a very large number of vadose zone injection wells would be required to achieve the overall recharge capacity of infiltration basins. In addition, rehabilitation of the wells to remove the effects of borehole wall plugging could be difficult if not impossible.

5. Depth to groundwater level at the site is only about 100 to 110 feet, which could limit long-term recharge capacity depending on the hydraulic properties of the saturated zone. As groundwater level rises during recharge operations, the horizontal permeability of sediments within (especially) the upper part of the aquifer and lower part of the pre-recharge vadose zone is critical in transmitting

water laterally away from the site at a sufficient rate to limit the magnitude of groundwater mounding. If most of the vadose zone thickness and upper part of the saturated zone are fine-grained as is indicated by the drillers' logs, the likely small permeability of this interval might limit the capacity for lateral flow and dissipation of the recharge mound despite the generally large transmissivity of the basin-fill deposits aquifer indicated by pumping tests (which may be largely due to the highly fractured basalt-flow unit). However, if the lower part of the vadose zone and upper part of the saturated zone are also very transmissive, there might be relatively rapid dissemination of groundwater mounding during recharge operations, which would allow substantial recharge volumes despite the relatively shallow depth to water.

6. Related to the development of a groundwater mound due to recharge operations is the proximity and rates of recharge at other potential nearby site(s). Our understanding is that the only active recharge site anywhere near the proposed recharge site is the Town's effluent recharge ponds at the wastewater treatment plant (WWTP), located about 8 miles southeast from the proposed recharge site. Current effluent recharge rates are on the order of 400,000 gallons per day (450 AF/yr), and are projected to eventually increase to about 1,000,000 gallons per day (1,120 AF/yr). Due to the relatively large distance of the WWTP recharge basins and locations of potential future injection wells from the proposed recharge site, and due to the small current and planned recharge rates at these facilities, relatively little groundwater level rise would be anticipated at the proposed site due to these other recharge activities. Therefore, impacts of other existing or planned recharge projects on groundwater level rise at the proposed site are believed to be minimal.

Estimated Recharge Capacity

Although a reliable determination of recharge capacity cannot be supported by the available data, preliminary estimates of recharge capacity can be made based on reasonable assumptions supported by the available data, which might provide sufficient basis for evaluating recharge feasibility for the site. Preliminary estimates were made using reasonable high- and low-end estimates for sustainable infiltration rate, which are empirically based on previous experience with other recharge sites and/or infiltration testing, with the focus on sites that consist of relatively fine-grained sediments in the near-surface zone. In addition, a conceptual layout of basins provided by Town of Chino Valley was used as an initial basis for calculations; the conceptual basin layout is shown on **Figure 3**. Assumptions for this simple analysis are summarized as follows:

- Eleven basins with a total infiltration area of about 36 acres are distributed within the excavated sand and gravel pit over the south half of the 75-acre parcel; the basins are closely spaced to maximize infiltration area and the basin floors would essentially be the top of a thick, generally "fine-grained" interval.
- Two infiltration rates will be used to provide a range of estimates of recharge capacity: 1.5 and 0.5 feet per day (ft/day). Based on previous experience and testing at many recharge sites, these infiltration rates are believed to be reasonable estimates for framing the range of rates for "fine-grained" sediments that might range from sandy silt/silty sand to a sandy clayey silt.
- Each basin would be actively filled and used two-thirds of the time, and allowed to dry out one-third of the time (duty cycle of 2:1). The drying period would be required for basin rehabilitation/maintenance.

Based on these reasonable assumptions, the high-end estimate of recharge capacity controlled by the generally fine-grained sediments underlying the basins would be computed as follows:

R = A · I · f = **13,200 AF/yr**

where:
R = recharge capacity in AF/yr
A = total recharge basin area = 36 acres
I = average sustainable infiltration rate = 1.5 ft/day = 548 ft/year
f = fraction of time that basins are filled = 0.667

Assuming an infiltration rate of 0.5 ft/day, the low-end estimate of recharge capacity is computed to be: **4,400 AF/yr**.

If additional basins would eventually be constructed in the north half of the parcel (**Figure 3**), recharge capacity would increase correspondingly. For example, based on the approach and assumptions above, 20 acres of additional basins would increase the potential range of recharge capacity to about **6,800 to 20,400 AF/yr**.

These estimated ranges of potential recharge capacity for surface infiltration basins are large due to the absence of reliable data for subsurface lithology and associated infiltration rates. If the actual vadose zone sediments underlying the basin floor are predominantly "silty sand/sandy silt (i.e. roughly 50 percent sand and 50 percent silt, with minor clay), the high-end estimate of 13,200 AF/yr for the initial basins is more likely to be representative of the actual recharge capacity *of the vadose zone* (neglecting potential reductions due to excessive groundwater mounding). Conversely, if the sediments are predominantly silty and clayey, the low-end estimate of 4,400 AF/yr is more likely to be representative, and it's even possible that the infiltration capacity could be smaller than this estimate if the sediments directly underlying the basins are cemented and/or very clayey. Using the median value for the computed ranges, which is equivalent to assuming an infiltration rate of 1 ft/day, might be a reasonable approach, but using a value closer to the low-end estimate may be a more prudent approach, especially after incorporating groundwater mounding considerations, addressed in the following paragraphs.

The second crucial element of this simple analysis is depth to groundwater. The infiltration capacities estimated above are controlled by the vadose zone sediments, based on the stated assumptions. As described previously, the amount of groundwater level rise (mounding) during recharge operations will depend on the permeability of sediments in (especially) the upper part of the aquifer and lower part of the pre-recharge vadose zone. Due to the relatively shallow depth to groundwater at the proposed recharge site (100 to 110 feet bls), if a large infiltration capacity is achieved through the surface basins, it is possible that groundwater level rise could reach the bottom of the basins and limit hydraulic loading. To estimate the magnitude of groundwater mounding that would result from given recharge rates and/or estimate the maximum recharge rate before groundwater mounding would reach the floor of the basins, a numerical model would need to be constructed and site-specific lithologic and hydraulic data would have to be obtained. In the absence of this modeling approach, examination of recharge rates and measured groundwater level rise at a "reasonably similar" active recharge project site provides a basis of comparison for evaluating the potential for excessive groundwater level rise at the proposed recharge site. At a site in southern Arizona where pre-recharge depth to groundwater level was about 140 feet, recharge of about 10,000 AF/yr for 2 years using 14 acres of closely-spaced basins resulted in about 60 feet of groundwater level rise at the basins. The vadose zone at this site consisted chiefly of silty sand and gravel, but included several relatively thick and continuous layers of silt and clay, and the transmissivity of the underlying unconfined aquifer might be relatively similar to that of the "upper part of the aquifer" at the proposed recharge site, so hydrogeologic conditions at the two sites might be sufficiently similar to allow at least a rough projection of groundwater level rise.

At the proposed recharge site, assuming the floor of the basins would be at a depth of about 22 feet, depth to (current) groundwater level below the basins is approximately 80 feet. Based on the groundwater mounding results at the southern Arizona site, and considering that a groundwater mound would continue to build with time (albeit at a decreasing rate), a recharge rate *on the order of* 10,000 AF/yr might be a reasonable preliminary estimate if recharge rate would be constrained by groundwater mounding due to the relatively shallow depth to groundwater. This analysis serves to demonstrate that even if the vadose zone infiltration capacity is much larger than is inferred by the clayey lithology described in the drillers' logs, the shallow depth to groundwater could limit sustainable recharge rates using the closely spaced basins.

GROUNDWATER QUALITY

Groundwater quality impacts from recharge operations could also affect recharge feasibility and present a fatal flaw. Unreasonable harm issues could result either from degradation of ambient groundwater quality due to recharge using poorer quality source water, or displacement ("pushing") of poor-quality ambient groundwater outward to locations with better ambient groundwater quality. Groundwater quality impacts will depend on the quality of the source water used for recharge, ambient groundwater quality, and applicable regulatory standards. To evaluate potential impacts, site-specific and regional groundwater quality data would have to be obtained and evaluated together with source water quality data.

As a preliminary evaluation of ambient groundwater quality, available laboratory results were downloaded from the USGS website for groundwater samples obtained from three wells located within 2 miles of the proposed recharge site: (B-17-02)04aaa; (B-17-02)09dba; and (B-17-02)02cac. The samples were all obtained in March 2003 and were analyzed for numerous inorganic constituents, including common constituents and trace metals. The laboratory results for the three wells sampled (not tabulated in this report) are generally very similar and indicate good water quality with no exceedances of Aquifer Water Quality Standards (AWQS) established by Arizona Department of Environmental Quality (ADEQ). The one notable detection was for arsenic, which was detected at concentrations of 0.013 and 0.014 milligrams per liter in the three samples, which are slightly larger than the U.S. Environmental Protection Agency (EPA) Primary Maximum Contaminant Level (MCL) of 0.010 mg/L but still smaller than the AWQS of 0.050 mg/L. Arsenic is commonly detected at concentrations larger than the EPA primary MCL in many groundwater basins in Arizona. If the arsenic concentration in groundwater at the recharge site is similar to the concentrations detected in these three wells, arsenic would not be a limitation for recharge operations.

Although these laboratory results are for wells that are not at the proposed recharge site, they are reasonably close and provide a preliminary basis for concluding that ambient groundwater beneath the site is likely to be of good quality. As described subsequently in this report, due to the absence of apparent contamination sources at the site, elevated concentrations of constituents of concern would not be expected.

SURFACE WATER/FLOODPLAIN CONDITIONS

The primary drainage channels in the vicinity of the proposed recharge site are the Big Chino Wash, which transects the site from northwest to southeast, and the Williamson Valley Wash, which joins the Big Chino Wash approximately 1/4-mile south (downstream) from the site (**Figures 1 and 2**). The Big Chino Wash continues about 1.5 miles southeast and drains into Sullivan Lake north from the Town of Chino Valley. The common floodway and 100-year flood hazard area of the Big Chino Wash are shown on **Figure 1** for the vicinity of the proposed recharge site, and indicate that the entire site lies within both of these mapped flood zones. The 100-year flood hazard area should be considered an approximate estimate of the maximum area of inundation associated with a 100-year flood event (was determined by the Federal Emergency Management Agency - FEMA - using "approximate methods"), whereas the common floodway is the result of more careful mapping (in the late 1990's for the Paulden area) and delineates the area that conveys typical flood flows (is the legally enforceable area for requiring impact analysis for development). At the recharge site, the common floodway and 100-year flood hazard area are essentially the same area due to the relatively flat topography surrounding the site.

The sand and gravel mine (excavated pit), and therefore, future recharge basins are located within the common floodway in close proximity to the Big Chino Wash and the basins will be at a depth of 22 feet or more below the floodway level. The obvious susceptibility of the basins to flooding is presumably going to be addressed by construction of an engineered berm along the top of the north pit boundary, as indicated on the conceptual basin layout shown on **Figure 3**. It is also likely that an engineered berm would be required on the top of the west pit boundary adjacent to Williamson Valley Wash (**Figure 1**). Evaluation of the engineering design to prevent filling and associated erosion/degradation of the pit and basins is beyond the scope of this Phase 1 evaluation. However, it is crucial to note that even if the berms are successful in preventing flood flows from entering the pit, water that infiltrates into the subsurface during a flow event, especially in the Big Chino Wash channel, would likely intercept the pit wall and seep into the pit, leading to erosion or slumping of the pit wall sediments. The likelihood and/or extent of possible seepage and pit wall damage is difficult to estimate, but would be minimized by increasing the distance between the primary channel and the pit. This design might reduce the area of the pit floor, and therefore, the infiltration basin area. In addition, the engineered berm should be constructed as close to the primary channel as possible, to maximize the distance between flood flows and the pit, which might require more hydrologic studies of the Big Chino Wash and Williamson Valley Wash floodplains.

OTHER FEASIBILITY FACTORS

As described previously, there are many "non-hydrogeologic" factors that need to be considered in evaluating overall recharge feasibility, including: regulatory constraints, proximity to the source water supply, construction and operation costs, nearby land and water uses, and potential nearby contamination sources. Regulatory constraints are essentially being addressed in association with the other factors, as appropriate, especially regarding potential unreasonable harm issues with adjacent land and water users. Assessment of proximity to source water supply will depend on what the source will be; this factor will become pertinent when the source is identified and may initiate the consideration of other recharge sites that might become available. Evaluation of construction and operation costs is beyond the scope of this Phase 1 assessment, but there is an apparent advantage of this site due to the Town's third-party agreement with the mining company to construct bermed basins on the floor of the excavated pit, and perhaps other earthen features such as a perimeter berm/wall, in exchange for the mined sand and gravel. However, it is important to note that a cost analysis for this site needs to also incorporate the potential design elements and/or structures required to prevent flood flows into the pit and erosion or slumping of the pit walls due to subsurface seepage, described previously.

Nearby land and water uses that could be negatively affected by, or could negatively affect recharge operations at the proposed recharge site are important to identify and evaluate. Available data for land ownership, land uses, water (well) uses, and potential contaminant sources in the vicinity of the proposed recharge site was obtained from ADEQ, Yavapai County, and ADWR. Well locations and land ownership for the vicinity of the site is shown on **Figure 1**; the two primary groupings of ownership are State Trust Land and private land. The aerial photograph site map shown on **Figure 2** can be used to help identify potential land uses. In addition, a field reconnaissance of the vicinity of the site was conducted in May 2008 by Town of Chino

Valley staff and an M&A hydrogeologist to identify potentially sensitive nearby land uses and/or indications of potential contamination sources. Inspection of **Figures 1 and 2** in combination with the field reconnaissance indicates that:

- The south part of the proposed recharge site appears to have been used for agriculture, although the timeframe for this land use was not determined.
- Most or all of the State Trust Land in the vicinity of the proposed recharge site is generally undeveloped and includes very few wells, although the State Trust Land adjacent to the east boundary of the site includes some agricultural use.
- Private land south from and adjacent to the south boundary of the site and southwest from the site, to a distance of about 1/4-mile, also includes agricultural use and/or livestock grazing. It is also possible that the relatively undeveloped land adjacent to the west and north site boundaries may be used for livestock grazing, although this has not been confirmed.
- Non-active sand and gravel mines are located about 1/4-mile west and 1/4 to 1/2-mile northwest from the recharge site; these mines are located adjacent to the Williamson Valley Wash and Big Chino Wash, respectively. Based on results of field reconnaissance and on personal communication with Town staff, the pit for the retired mine located directly west from the site has been backfilled to a large degree and is relatively shallow (residual pit depth is on the order of several feet). The pit for the retired mine located northwest from the site is perhaps 15 feet deep.
- Low-density residential parcels occupy the remaining private land in the vicinity of the site, with the closest units generally occurring about 1/4-mile to the northeast. Many private domestic wells were installed in these residential areas. These residences are believed to be non-sewered and therefore would likely have septic systems.
- The vast majority of wells in the vicinity of the site are domestic wells, as noted in **Table 1**; the few remaining wells are indicated to be used for irrigation, commercial supply, and testing. Disregarding the two wells within the site boundary, the only registered wells within 1/4-mile of the site are (B-17-02)04bdd and (B-18-02)33ccc (**Figure 1**). The well in Section 4 is a test well owned by the City of Prescott and the well in Section 33 is a domestic well.

Agricultural land use would typically include the use of herbicides, pesticides, and fertilizers, all of which could be potential contaminants. However, the topsoil being excavated and removed at the proposed recharge site would be expected to contain most of any herbicides and pesticides that might have been applied because they are generally strongly sorbed to soil organic material. Nitrate levels in groundwater beneath agricultural lands are often elevated due to deep leaching of nitrates. Therefore, it would be prudent to sample and test groundwater at the proposed site for the possible occurrence of nitrates, as wells as herbicides and pesticides. Despite this recommendation, due to the relatively small area of the (apparent) agricultural lands at and surrounding the site, it is not likely that substantial (if any) contamination of groundwater has occurred.

The sand and gravel mines near the proposed recharge site are not active, and therefore, would not pose a concern for unreasonable harm due to recharge operations at the site. Because the pit for the non-active mine located northwest from the site is apparently still open to a depth of perhaps 15 feet, it might be possible that the mine could be reactivated in the future. However, if the mine would be reactivated, the depth of recoverable sand and gravel is likely limited to 20 or 30 feet (based on conditions encountered at the proposed recharge site). Therefore, it is unlikely that water level rise associated with recharge operations at the proposed site would intercept this pit or otherwise cause unreasonable harm.

The occurrence of numerous residences in the vicinity of the proposed recharge site that are likely to have septic systems represents a potential source of contaminants in the vadose zone due to the percolation of effluent through the leach fields, especially considering the relative shallow depth to groundwater. In particular, nitrate concentrations could be elevated relative to the regulatory limit. The vast majority of residences that would have septic systems are located more than 1/4 to 1/2-mile from the site, but it is possible that groundwater mounding during recharge operations could eventually cause groundwater with elevated nitrate concentrations at these locations (if it occurs) to migrate and/or cause nitrate previously in the vadose zone to enter the aquifer.

Therefore, investigations would need to be conducted to determine if existing nitrate concentrations in the vicinity of the site could lead to unreasonable harm issues during recharge operations.

The occurrence of numerous domestic wells in the vicinity of the proposed recharge site could be a notable concern depending on the source water to be recharged. On one hand, rising groundwater levels resulting from recharge operations are not likely to cause unreasonable harm to the domestic wells, and could be beneficial to offset potential future groundwater level declines if pumping in this part of the sub-basin would increase. However, if the source water quality is poorer than the ambient groundwater quality, recharge operations could eventually cause degradation of the water quality of the domestic supply wells, which may have to be mitigated depending of the extent of degradation and occurrence of any constituents of concern.

In addition to field reconnaissance and inspection of the aerial photograph, federal, state, and county databases for potential contamination sources were searched, including: Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) sites regulated by the EPA; U.S. Department of Defense sites; Water Quality Assurance Revolving Fund (WQARF) sites and leaking underground storage tanks (LUST sites) regulated by ADEQ; and landfills regulated by Yavapai County. These searches indicated that no contaminant sites registered in these databases were found in the vicinity (for many miles) of the proposed recharge site. Although these database searches do not rule out the possible occurrence of any and all contaminants near the site, combined with the site reconnaissance, they provide a preliminary basis for indicating no large-scale contaminant sources (disregarding the potential nitrate sources described previously).

SUMMARY AND RECOMMENDATIONS

The present Phase 1 report addresses several hydrogeologic and non-hydrogeologic factors to provide a preliminary evaluation of recharge feasibility at the Town's proposed recharge site near Paulden. This assessment was conducted based on available data obtained for the vicinity of the site for: hydrogeologic conditions, land and water uses, potential contaminant sources, and other parameters. The pertinent findings of this assessment can be summarized as follows:

- Due to the absence of site-specific data to characterize lithologic and hydraulic conditions of the vadose zone and saturated zone at the site, an estimate of infiltration rates (for surface basins), injection rates (for vadose zone wells), and overall recharge capacity for the site cannot be prepared with a high level of confidence.

- Based on the general characterization provided in drillers' logs that the vadose zone and upper part of the saturated zone are relatively fine-grained, a range of estimates of recharge capacity was prepared for the initial conceptual layout of 36 acres of infiltration basins that would be constructed in the pit excavated by the sand and gravel operator. Based on "reasonable" high-end and low-end infiltration rates of 1.5 and 0.5 ft/day and a 2:1 wetting to drying cycle, recharge capacity is estimated to range from 4,400 to 13,200 AF/yr based solely on vadose zone conditions. For a potential basin area of 56 acres at full build-out, recharge capacity is estimated to range from 6,800 to 20,400 AF/yr.

- Due to the relatively shallow depth to groundwater, if infiltration capacity of the vadose zone would be relatively large (toward the upper end of the estimated range stated above), recharge capacity for the site may still be limited by groundwater level rise to the floor of the basins. Based on recharge rates and observed groundwater level rise at another "comparable" recharge site, recharge capacity at the proposed recharge site might be limited to 10,000 AF/yr or less based on groundwater level rise constraints. However, if vadose zone conditions can support an infiltration rate of close to 1.5 ft/day, and if the transmissivity of the upper part of the aquifer and lower part of the pre-recharge vadose zone at the site is very large, the higher end of the recharge capacity estimates stated above might be achievable.

- Based on review of readily available information for nearby land and water uses and potential contaminant sources, including federal, state, and county database searches, review of aerial photographs, and field reconnaissance, there do not appear to be significant constraints or fatal flaws for recharge operations due to these non-hydrogeologic factors. However, it is highly recommended that a more thorough examination of the site and the adjacent areas should be conducted to identify any less apparent contaminant sources or unreasonable harm issues, especially with regard to possible nitrate sources.

- Based on the hydrogeologic considerations described for this assessment, and based on the apparent absence of potential fatal flaws associated with nearby land and water uses, contaminant sources, groundwater quality, and other factors, it is likely that the proposed recharge site would accommodate the Town's initial recharge goals of storing between 4,000 to 8,000 AF/yr. However, due to the absence of site-specific data and to the uncertainty of assumptions on which this estimate is based, it would be prudent to use the lower end of this estimated range for the Town's planning purposes.

If the Town decides to further pursue development of a recharge facility at this site, it is clear that site-specific investigations need to be conducted to provide data for more detailed lithologic and hydraulic characterization of the subsurface sediments underlying the floor of the (potential) recharge basins and to provide a more accurate evaluation of recharge feasibility. Results of these site-specific investigations would also provide required data for the regulatory permits, including the Underground Storage Facility (USF) and Water Storage permits through ADWR and the Aquifer Protection Permit through ADEQ. Finally, assuming that the size and shape of the current sand and gravel pit will be dictated by the mining company, results of these investigations could still provide information that might assist in the design of the pit and basins in the "north half" of the site (several years in the future) and/or for determining the use and design of vadose zone or saturated zone injection wells. The site investigations should include:

1. drilling and sampling of several exploration boreholes across the site to depths of 80 feet or more to evaluate vadose zone lithology;
2. drilling of shallow boreholes or excavation of trenches in the floor of the sand and gravel pit (when finished) to more thorough characterize the shallow subsurface conditions immediately underlying the basins;
3. conduct of infiltration tests to provide data for estimating infiltration capacity of the basins;
4. installation and testing of one or two wells to characterize lithologic and hydraulic properties of the upper part of the aquifer, and to obtain groundwater samples for characterizing groundwater quality (the wells could then be used as monitor wells if/when the site is permitted as an USF).

In addition to the site-specific investigations, it is highly recommended that investigations be conducted to evaluate non-hydrogeologic factors to rule out potential fatal flaws or substantial constraints to recharge goals. Specifically, a more thorough examination of the site and the nearby properties should be conducted to identify contaminant sources or unreasonable harm issues that might be less apparent or more sensitive than the sources or issues that could be identified for the Phase 1 assessment. This would include a comprehensive reconnaissance and/or database search of land and water uses, and well locations and completion depths, wildcat dumps, chemical spills, underground storage tanks, septic systems, and other potential contaminant sources. These investigations/searches would also be necessary to meet ADWR and/or ADEQ requirements for the USF and APP permitting process.

It is also recommended that a more complete compilation and evaluation of existing water quality data be conducted to better characterize ambient groundwater quality in the vicinity of the proposed recharge site. As stated previously, data for nitrate concentrations in groundwater in the vicinity of the site should be compiled and evaluated, which would likely also include sampling of selected wells to obtain more current data than is available. In addition, information on the expected chemical quality of the source water to be stored should be evaluated and compared to ambient groundwater quality. Effects of recharge on chemical quality of groundwater would need to be addressed to evaluate potential unreasonable issues and obtain regulatory permits.

The next phase of investigations should also include conduct of a groundwater mounding analysis for the site using a computer-based groundwater flow model to further evaluate the effects of possible recharge rates and volumes; inputs to the model would include regional hydrogeologic data already compiled together with site-specific data obtained from the investigations recommended above. Results of this groundwater model would also be required for the regulatory permits.

It is also important to note that for the present Phase 1 assessment, the overriding assumption is that surface infiltration basins would be the primary means of recharge, perhaps with vadose zone injection wells added. This assumption is based on the agreement that the mining company would construct basins in exchange for mining sand and gravel from the site, and on the initial plan for the source water to be treated effluent. However, if the source water is good quality imported groundwater, direct injection into the aquifer may be the most cost effective and technically feasible option, or at least an important component of the recharge facility, and it would be highly recommended to consider direct injection.

Finally, pit design and construction issues related to preventing inundation from flood flows and subsurface seepage through the pit walls should be investigated. This task should probably be conducted by Town engineers or outside engineering consultant.

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TABLE 1. WELL INVENTORY FOR VICINITY OF PROPOSED RECHARGE SITE NEAR PAULDEN, YAVAPAI COUNTY, ARIZONA

CADASTRAL LOCATION	ADWR 55-WELL REGISTRY NUMBER	DATA SOURCE[a]	OWNER	DATE COMPLETED	DEPTH DRILLED (feet)	CASING			ALTITUDE (ft, msl)[c]	WATER LEVEL		PUMPING RATE (gpm)[d]	WATER USE[e]	DRILLER'S LOG	REMARKS
						DIAM. (inches)	DEPTH (ft, bls)[b]	PERF. (ft, bls)		DATE	DEPTH (feet)				
(B-17-02) 03AAA	561796	55	ABRA WATER CO INC	—	400	14	208	—	—	—	136	450	COM	X	—
(B-17-02) 03BAD	201547	55	EDWARD MCCONNELL	2/2/2004	265	6	265	—	—	2/2/2004	160	—	DOM	X	—
(B-17-02) 03BBA	553511	55	BILL SHIEW	2/14/1996	261	7	260	—	—	2/14/1996	1622	—	DOM, IRR	X	—
(B-17-02) 03CBB	594636	55	JAN KARBOWNIOZEK	10/23/2002	265	6	260	—	—	10/23/2002	161	—	DOM	X	Abandoned
(B-17-02) 03CBB1	603009	GWSI	CHARLES SMITH	1/1/1926	167	6	0-20	—	4405	—	—	—	DOM	—	—
(B-17-02) 03CBB2	—	GWSI	—	1/1/1960	201	8	0-100	—	4406	2/24/1999	141.7	—	PUB	—	—
(B-17-02) 03CBC	592029	55	DEBORAH GRAY	—	215	6	215	—	—	—	144	—	DOM	X	—
(B-17-02) 03CBC	596602	55	JAN KARBOWNIOZEK	1/22/2003	260	6	250	—	—	1/22/2003	149	—	PROD	X	—
(B-17-02) 03CBD	501100	55	L B GILPIN	12/18/1981	255	6	20	—	—	12/18/1981	156	18	DOM	X	—
(B-17-02) 03CCB	592027	55	DEBORAH GRAY	—	236	6	198	—	—	—	142	—	DOM	X	—
(B-17-02) 03CCC	576553	55	JOSE L GRANILLO	9/10/1999	300	4	300	—	—	—	—	—	DOM	X	—
(B-17-02) 03CCD	—	GWSI	—	—	—	6	—	—	4430	4/27/2004	162.7	—	S	—	—
(B-17-02) 04AAA	525743	55, GWSI	STARR BENNETT LIVING TRUST	7/11/1989	298	8 6	0-19 18-298	178-298	4390	7/11/1989	145	100	IRR, S	X	—
(B-17-02) 04AAB	518978	55	MILES KILLIAN	9/2/1987	253	7	240	—	—	9/2/1987	125	90	DOM, IRR	X	—
(B-17-02) 04ABA	525215	55	STARR BENNETT LIVING TRUST	7/20/1989	298	8	298	—	—	7/20/1989	145	60	DOM, IRR	X	—
(B-17-02) 04ADD	503024	55	CHINO PROPERTIES	6/22/1982	260	10	20	—	—	6/22/1982	141	—	IRR	X	—
(B-17-02) 04BBC	505962	55	TIMOTHY & LISA COURY	2/29/1984	249	14	251	—	—	2/29/1984	111	—	IRR	X	—
(B-17-02) 04BCA	508963	55	TIMOTHY J COURY	11/7/1984	177	7	177	—	—	11/7/1984	101	—	DOM	X	—
(B-17-02) 04BDD	524077	55	CITY OF PRESCOTT	8/16/1989	242	2	220	—	—	8/16/1989	101	—	T	X	—
(B-17-02) 04CDA	609267	55	C B CARMER	—	200	20	60	—	—	—	104	3200	IRR	—	—
(B-17-02) 04DBC1	—	GWSI	CITY OF PRESCOTT	—	—	16	—	—	4362	3/27/2007	104	—	U	—	—
(B-17-02) 04DBC2	—	GWSI	—	—	—	—	—	—	4362	—	—	—	U	—	—
(B-17-02) 04DBC3	524078	55, GWSI	CITY OF PRESCOTT	8/22/1989	600	8	—	—	4362	—	—	—	T, U	X	25
(B-17-02) 04DBC3 PZ1	524078	55, GWSI	CITY OF PRESCOTT	8/22/1989	600	2	0-417	377-417	4362	2/24/1999	101.3	—	T, U	X	—
(B-17-02) 04DBC3 PZ2	524078	55, GWSI	CITY OF PRESCOTT	6/22/1989	600	1.5	0-249	209-249	4362	2/24/1999	101.6	—	T, U	X	—
(B-17-02) 04DBC3 PZ3	524078	55, GWSI	CITY OF PRESCOTT	—	600	—	—	—	4362	2/24/1999	101.2	—	T, U	X	—
(B-17-02) 04DBD	—	GWSI	—	—	—	6	—	—	4365	11/6/1990	102	—	U	—	—
(B-17-02) 04DCB	609277	55	CHINO PROPERTIES	—	—	6	—	—	—	—	—	35	S	—	—
(B-17-02) 04DDC	539660	55	EDDIE D SMITH	7/8/1993	200	7	200	—	—	7/8/1993	110	18	DOM	X	—
(B-17-02) 04DDD	569328	55	CHINO VALLEY FIRE DISTRICT	7/22/1999	240	7	240	—	—	7/22/1999	99	—	MUN	X	—
(B-17-02) 05BCA	563086	55	CHARLES HENRY WILFONG	6/25/1997	240	7	240	—	—	6/25/1997	116	—	DOM	X	—
(B-17-02) 05BCC	594326	55	RICK NARVESEN	—	260	6	260	—	—	—	144	—	DOM	X	—
(B-17-02) 05BDC	584401	55	TIM MILNER	—	240	6	240	—	—	—	—	—	DOM	X	—
(B-17-02) 05BDC	582492	55	DAVID & KAREN FETCHEN	6/15/2000	260	6	260	—	—	6/15/2000	126	—	DOM	X	—
(B-17-02) 05BDC	582906	55	DAVID & KAREN FETCHEN	9/21/2000	260	6	260	—	—	9/21/2000	122	—	S	X	—
(B-17-02) 05BDD	584399	55	PAT HERNANDEZ	—	—	7	240	—	—	—	—	—	DOM	—	—
(B-17-02) 05BDD	582193	55	WELDON & SANDRA M RUTLEDGE	8/23/2000	260	6	260	—	—	8/23/2000	120	—	DOM	X	—

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TABLE 1. WELL INVENTORY FOR VICINITY OF PROPOSED RECHARGE SITE NEAR PAULDEN, YAVAPAI COUNTY, ARIZONA

CADASTRAL LOCATION	ADWR 55-WELL REGISTRY NUMBER	DATA SOURCE[a]	OWNER	DATE COMPLETED	DEPTH DRILLED (feet)	CASING DIAM. (inches)	CASING DEPTH (ft, bls)[b]	CASING PERF. (ft, bls)	ALTITUDE (ft, msl)[c]	WATER LEVEL DATE	WATER LEVEL DEPTH (feet)	PUMPING RATE (gpm)[d]	WATER USE[e]	DRILLER'S LOG	REMARKS
(B-17-02) 05CBA	609278	55, GWSI	BERT CAMPBELL FAM TR	---	380	8	20	---	4398	4/29/2004	142.1	---	S	---	12" casing in GWSI
(B-17-02) 05CBC	576048	55	ARNOLD MURRAY	7/22/1999	265	4	265	---	---	7/22/1999	150	---	DOM	X	---
(B-17-02) 05CBD	576747	55	RICHARD MICHAEL	8/16/1999	270	4	270	---	---	8/16/1999	160	---	DOM	X	---
(B-17-02) 05CCA	581177	55	ROBERT MCDONALD	5/26/2000	280	5	280	---	---	---	---	---	COM	X	---
(B-17-02) 05CCB	567666	55	RICHARD MICHAEL	4/26/1999	270	7	170	---	---	4/26/1999	170	---	DOM	X	---
(B-17-02) 05CCC	562706	55	RICHARD MICHAEL	---	---	---	---	---	---	---	---	---	IRR	---	---
(B-17-02) 05CCC	568261	55	SOUTHWEST LAND & CATTLE CO	5/30/1998	375	8	375	---	---	5/30/1998	120	---	DOM	X	---
(B-17-02) 05CCC	588597	55	RICHARD MICHAEL	11/17/1999	265	7	265	---	---	11/17/1999	120	---	IRR	X	---
(B-17-02) 05CCC	588100	55	RICHARD MICHAEL	---	646	12	620	---	---	---	280	---	IRR	X	---
(B-17-02) 05CCC	587131	55	RICHARD MICHAEL	6/27/2001	265	5	260	---	---	6/27/2001	132	---	DOM	X	---
(B-17-02) 05CDA	589008	55	REBECCA BOCK	1/3/2002	340	6	340	---	---	---	---	---	DOM	X	---
(B-17-02) 05CDB	580981	55	ROBERT A BARNETT	6/27/2000	300	5	300	---	---	---	---	---	DOM	X	---
(B-17-02) 05CDB	589731	55	TRACIE HOLLOWAY	2/13/2002	320	5	320	---	---	---	---	---	DOM	X	---
(B-17-02) 05CDC	587547	55	GARY S AND CHERE R WARREN	---	280	7	280	---	---	---	150	---	DOM	X	---
(B-17-02) 05CDD	590974	55	GLENN TARR	3/25/2002	320	5	320	---	---	---	---	---	DOM	X	---
(B-17-02) 05CDD	599563	55	ROBIN A. WINTERS	1/3/2003	320	5	320	---	---	---	---	---	DOM	X	---
(B-17-02) 05DCB	590758	55	ROBERT NORRIS	2/21/2002	380	6	363	---	---	2/21/2002	160	---	DOM	X	---
(B-17-02) 05DCC	598982	55	MURRELL WORTH	---	---	---	---	---	---	---	---	30	DOM	---	---
(B-17-02) 08ADD	803386	GWSI	ARIZONA STATE LAND DEPT	---	650	16	---	---	4402	2/25/1999	137.3	---	S	---	---
(B-17-02) 09000	528176	55	COLORADO HARLAN	11/29/1989	---	---	---	---	---	11/29/1989	80	---	NONE	X	---
(B-17-02) 09AAA	542962	55	W L JOHNSTON	6/23/1994	147	7	147	---	---	6/23/1994	75	---	IRR	X	---
(B-17-02) 09AAB	597629	55	VALERIE HLADKI	---	305	5	305	---	---	---	140	---	DOM	X	---
(B-17-02) 09AAC	535321	55	JUBE & PERIDAWN HAWTHORNE	6/21/1992	216	7	216	---	---	6/21/1992	112	28	DOM	X	---
(B-17-02) 09ABC	514774	55	BIG CHINO LAND COMPANY	7/9/1986	149	6	147	---	---	7/9/1986	104	75	DOM, S	X	---
(B-17-02) 09ABD	598102	55	BIG CHINO LAND COMPANY	3/16/2004	160	20	20	---	---	3/16/2004	130	---	IRR, S	X	---
(B-17-02) 09ACC	573337	55	ROMUALOUS & CHRISTINA TEN BERGE	3/30/1999	230	4	230	---	---	3/30/1999	135	---	DOM	X	---
(B-17-02) 09ACC	575639	55	ROMAULDUS TEN BERGE	7/19/1999	190	4	190	---	---	7/19/1999	138	---	S	X	---
(B-17-02) 09ADC	598376	55	IRVIN HOOPES	7/18/2003	308	6	300	---	---	7/18/2003	172	60	DOM	X	---
(B-17-02) 09BBA	576482	55	JOSE F BELTRAN	---	285	7	285	---	---	---	180	---	DOM	X	---
(B-17-02) 09BBA	576092	55	KAREN LUNDAHL	7/14/1999	280	4	280	---	---	---	---	---	DOM	X	---
(B-17-02) 09BBC	537360	55	JOHN & SUSAN BOUILLETTE	3/23/1993	200	7	200	---	---	---	---	---	DOM	X	---
(B-17-02) 09BBC	537361	55	BIG CHINO LAND CO	4/8/1993	207	7	207	---	---	4/8/1993	145	---	DOM	X	---
(B-17-02) 09BCC	609269	55, GWSI	BERT CAMPBELL FAMILY TRUST	1/1/1956	250	19	160	---	4390	9/1/1972	142.3	2300	IRR	---	---
(B-17-02) 09BCD	593436	55	MARK A J & ILEEN M ISZA	7/26/2002	165	5	165	---	---	7/26/2002	130	10	DOM	X	---
(B-17-02) 09BDC	200314	55	ROY TAYLOR	9/26/2003	200	5	200	---	---	9/26/2003	124	---	DOM	X	---

ERROL L. MONTGOMERY & ASSOCIATES, INC.

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						DIAM. (inches)	DEPTH (ft, bls)[b]	PERF. (ft, bls)		DATE	DEPTH (feet)				
(B-17-02) 09BDD	578456	55	CARL JOHNSON	8/27/1999	120	4	120	—	—	8/27/1999	90	—	DOM	X	—
(B-17-02) 09CAA	573687	55	PHILLIP K & BRANDY L FLORENCE	4/8/1999	165	6	165	—	—	4/8/1999	118	—	DOM	X	—
(B-17-02) 09CAA	579948	55	JOHN & JULIE AYERS	8/9/2000	180	6	180	—	—	—	—	—	DOM	X	—
(B-17-02) 09CAA	586039	55	JAMES & VAL GUSTAFSON	3/29/2001	292	6	280	—	—	3/29/2001	160	—	DOM	X	—
(B-17-02) 09CAB	509282	55	CYNTHIA M LEACH	8/14/1984	260	6	260	—	—	8/14/1984	160	12	DOM	X	—
(B-17-02) 09CAB	573666	55	MAX HAUK	4/15/1999	270	6	253	—	—	4/15/1999	159	—	DOM	X	—
(B-17-02) 09CAB	573669	55	JOHN D JUSTICE	4/8/1999	210	6	210	—	—	4/8/1999	130	22	DOM	X	—
(B-17-02) 09CAB	577163	55	ROSSMARY RIDDLE	10/13/1999	270	4	170	—	—	10/13/1999	164	—	DOM	X	—
(B-17-02) 09CAB	582491	55	RICHARD & ALICE MERRIMAN JR	8/30/2000	450	6	450	—	—	8/30/2000	197	—	DOM	X	—
(B-17-02) 09CAB	—	GWSI	BIG CHINO LAND COMPANY	—	—	—	—	—	4379	7/20/1992	107.1	—	DOM	—	—
(B-17-02) 09CAC	514311	55	MIKE BALOG	6/3/1986	289	—	270	—	—	6/3/1986	175	60	IRR	X	—
(B-17-02) 09CAC	545397	55	TERRY ZEHNDER	9/24/1994	213	7	213	—	—	9/24/1994	140	—	DOM, IRR	X	—
(B-17-02) 09CAD	576356	55	CASSIE GAHR	8/23/1999	256	4	240	—	—	8/23/1999	160	—	DOM	X	—
(B-17-02) 09CAD	588362	55	THOMAS HAMBLEN	8/24/2001	280	6	280	—	—	—	—	—	DOM	X	—
(B-17-02) 09CAD	593288	55	ROBERT B & PATSY R JENSEN	—	370	6	363	—	—	—	200	—	DOM	X	—
(B-17-02) 09CBA	502977	55	RICHARD GOIK	6/10/1982	236	6	20	—	—	6/10/1982	160	—	DOM	X	—
(B-17-02) 09CBA	520296	55	FRANCIE L RIOS	2/24/1989	236	7	230	—	—	2/24/1989	165	19	DOM	X	—
(B-17-02) 09CBB	535274	55	RON LARSON	6/13/1992	230	7	220	—	—	6/13/1992	169	—	DOM	X	—
(B-17-02) 09CBC	543647	55	ANTHONY LAMBRECHT	6/8/1994	267	7	267	—	—	6/8/1994	175	—	DOM	X	—
(B-17-02) 09CBC	565749	55	DENNIS D DINGLEY	6/21/1998	295	7	295	—	—	—	—	—	DOM	X	—
(B-17-02) 09CBC	578043	55	STARLYN DUPREE	—	272	7	265	—	—	—	383	—	DOM	X	—
(B-17-02) 09CBC	584013	55	STREETMAN FAMILY LIMITED PARTNERSHIP	—	430	6	418	—	—	—	172	—	DOM	X	—
(B-17-02) 09CBD	565308	55	PAM AND JOHN AYERS	9/18/1998	300	7	300	—	—	9/18/1998	180	—	DOM	X	—
(B-17-02) 09CBD	573602	55	DANIEL & FRANCES BRAYMAN	4/14/1999	270	6	260	—	—	4/14/1999	162	12	DOM	X	—
(B-17-02) 09CCA	543219	55	MARK MODRAK	4/14/1994	272	7	272	—	—	4/14/1994	173	—	DOM	X	—
(B-17-02) 09CCB	505936	55	C H MYERS	6/14/1984	270	7	20	—	—	6/14/1984	197	16	DOM	X	—
(B-17-02) 09CCB	512761	55	DALE W PITNEY JR	11/8/1985	130	7	130	—	—	11/8/1985	80	40	DOM	X	—
(B-17-02) 09CCC	503039	55	LAZEAR & JOHNSTON	4/25/1983	280	6	20	—	—	4/25/1983	180	—	DOM	X	—
(B-17-02) 09CCC	546078	55	CLAYTON F NAYLOR	9/30/1994	320	7	320	—	—	9/30/1994	180	10	DOM	X	—
(B-17-02) 09CCC	550081	55	FRANK FAKINOS	8/18/1995	320	7	320	—	—	—	—	18	DOM	X	—
(B-17-02) 09CCC	584587	55	LARRY L & JUDY C DUBBS	—	295	7	295	—	—	—	160	10	DOM	X	—
(B-17-02) 09CCD	508199	55	J WHITE	11/1/1983	280	7	280	—	—	11/1/1983	180	—	DOM	X	—
(B-17-02) 09CCD	508303	55	MARK & VICTORIA MODRACK	6/19/1984	280	7	20	—	—	6/19/1984	188	12	DOM	X	—
(B-17-02) 09CCD	619175	55, GWSI	BIG CHINO LAND CO	12/31/1959	670	24 18	0-20 2-600	—	4410	1/1/1966	184.83	6000	DOM, S	X	09CCA in 55
(B-17-02) 09CDA	201758	55	IRVIN HOOPES	—	245	6	245	—	—	—	—	—	DOM	X	—
(B-17-02) 09CDA	513704	55	STANLEY ALLISON CIRZAN	4/25/1986	250	7	245	—	—	4/25/1986	160	12	DOM	X	—
(B-17-02) 09CDA	521490	55	TERRY R VERMILYEA	6/30/1988	250	7	250	—	—	6/30/1988	16	—	DOM	X	—

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TABLE 1. WELL INVENTORY FOR VICINITY OF PROPOSED RECHARGE SITE NEAR PAULDEN, YAVAPAI COUNTY, ARIZONA

CADASTRAL LOCATION	ADWR 55-WELL REGISTRY NUMBER	DATA SOURCE[a]	OWNER	DATE COMPLETED	DEPTH DRILLED (feet)	CASING DIAM. (inches)	CASING DEPTH (ft, bls)[b]	CASING PERF. (ft, bls)	ALTITUDE (ft, msl)[c]	WATER LEVEL DATE	WATER LEVEL DEPTH (feet)	PUMPING RATE (gpm)[d]	WATER USE[e]	DRILLER'S LOG	REMARKS
(B-17-02) 09CDA	539663	55	JERRY D. & SHARON V. DAWSON	4/19/1993	210	7	210	—	—	4/19/1993	100	—	DOM, IRR	X	—
(B-17-02) 09CDA	539960	55	BRIAN COMLY	6/15/1993	260	7	260	—	—	6/15/1993	162	10	DOM	X	—
(B-17-02) 09CDB	511117	55	C N PETERSON	7/2/1995	255	7	20	—	—	7/2/1995	169	—	DOM	X	—
(B-17-02) 09CDB	511603	55	HELENE C SCHEIDLER	7/3/1995	260	6	230	—	—	7/3/1995	170	12	DOM	X	—
(B-17-02) 09CDB	511937	55	J BRUCE	6/30/1995	260	7	259	—	—	6/30/1995	168	12	DOM	X	—
(B-17-02) 09CDB	513389	55	DEREK & RACHEL SANDERS	2/21/1996	280	7	259	—	—	2/21/1996	175	—	DOM	X	—
(B-17-02) 09CDB	550970	55	MARIALUISA YOSHIKAWA	8/30/1995	303	7	303	—	—	8/30/1995	180	10	DOM	X	—
(B-17-02) 09CDC	573340	55	BENITO G & VICTORIA M SANCHEZ	6/30/1999	280	4	280	—	—	6/30/1999	150	—	DOM	X	—
(B-17-02) 09CDD	525508	55	RAY ESTRADA	3/29/1989	263	7	263	—	—	3/29/1989	165	23	DOM	X	—
(B-17-02) 09CDD	592032	55	GERMAN MILLAN	—	355	6	330	—	—	—	147	—	DOM	X	—
(B-17-02) 09DAC	542600	55	GARY & TERESA L GLENN & ANDERSON	3/21/1994	235	7	235	—	—	3/21/1994	139	24	DOM	X	—
(B-17-02) 09DAC	573527	55	DARREN MENLOVE	3/23/1999	230	5	230	—	—	3/23/1999	130	—	DOM	X	—
(B-17-02) 09DBA	572449	55	EDWARD M GREULING	2/10/1999	190	7	190	—	—	2/10/1999	130	—	DOM	X	—
(B-17-02) 09DBA	594604	55	GHENT HOLMAN	10/3/2002	305	6	300	—	—	10/3/2002	139	—	DOM	X	—
(B-17-02) 09DBB	509434	55	ROBERT & PATRICIA EARLE	6/19/1994	380	5	380	—	—	6/19/1994	172	20	DOM	X	—
(B-17-02) 09DBB	587164	55	RICHARD & MARILYN BUSBY	7/31/2001	280	4	280	—	—	—	—	—	DOM	X	—
(B-17-02) 09DBC	515403	55	DONALD L HERMAN	9/12/1996	240	6	240	—	—	9/12/1996	140	20	DOM, IRR, S	X	—
(B-17-02) 09DBC	522376	55	JIMMIE LEE ROUTH	10/28/1988	240	7	240	—	—	10/28/1988	148	10	DOM	X	—
(B-17-02) 09DCB	570794	55	PAUL & DOUGLAS MERWIN	11/30/1998	240	4	240	—	—	11/30/1998	102	—	DOM	X	—
(B-17-02) 09DDA	582976	55	JEROME W & PENNY DEY	9/15/2000	305	5	305	—	—	9/15/2000	110	18	DOM	X	—
(B-17-02) 09DDB	547338	55	DANIEL PEREDA	1/31/1995	215	7	215	—	—	1/31/1995	140	—	DOM	X	—
(B-17-02) 09DDD1	633611	55, GWSI, 35	RICHARD PEARSON	10/25/1979	195	6	0-23	—	4365	10/16/1979	97	35	DOM, IRR	X	35-82505
(B-17-02) 09DDD2	512697	55, GWSI	RICHARD PEARSON	11/7/1985	130	7	1-19	—	4365	11/7/1985	100	35	DOM, IRR	X	—
(B-17-02) 10AAC	593528	55	ANTHONY SALAS	9/5/2002	345	6	345	—	—	9/5/2002	220	—	DOM	X	—
(B-17-02) 10CAB	208694	55	JAY & SUSAN DIAL	—	380	6	330	—	—	—	170	—	DOM	X	—
(B-17-02) 10CAC	519184	55, GWSI	JOHN D. HEIDEWALD	10/16/1987	310	7 5.5	0-20 0-310	140-310	4393	10/16/1987	135	—	IRR, DOM	X	—
(B-17-02) 10CAC	543494	55	ELLIOTT, BILL D	5/5/1994	250	7	250	—	—	5/5/1994	134	—	DOM	X	—
(B-17-02) 10CAD	599652	55	JEAN HARGESHEIMER	6/19/2002	330	5	320	—	—	6/19/2002	144	18	DOM	X	—
(B-17-02) 10CBA	504568	55, GWSI	VIRGINIA A. OESER	1/4/1983	275	6 5	0-20 0-275	—	4410	7/20/1992	164.3	19	DOM	X	—
(B-17-02) 10CBA	505430	55	ROBERT A SEYMOUR	7/11/1983	170	6	20	—	—	7/11/1983	138	35	DOM	X	—
(B-17-02) 10CBB	582373	55	STEVEN B GIANUZINA	—	325	5	325	—	—	—	138	—	DOM	X	—
(B-17-02) 10CBD	582140	55	DONALD P BRIGNER	7/27/2000	315	5	315	—	—	7/27/2000	135	10	DOM	X	—

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TABLE 1. WELL INVENTORY FOR VICINITY OF PROPOSED RECHARGE SITE NEAR PAULDEN, YAVAPAI COUNTY, ARIZONA

CADASTRAL LOCATION	ADWR 55-WELL REGISTRY NUMBER	DATA SOURCE[a]	OWNER	DATE COMPLETED	DEPTH DRILLED (feet)	CASING DIAM. (inches)	CASING DEPTH (ft, bls)[b]	CASING PERF. (ft, bls)	ALTITUDE (ft, msl)[c]	WATER LEVEL DATE	WATER LEVEL DEPTH (feet)	PUMPING RATE (gpm)[d]	WATER USE[e]	DRILLER'S LOG	REMARKS
(B-17-02) 10CDD	526611	55	CITY OF PRESCOTT	12/15/1989	285	10	260	—	—	12/15/1989	101	—	T	X	—
(B-17-02) 10DAA	509400	55	WELLS C	6/22/1994	240	7	20	—	—	6/22/1994	167	35	DOM	X	—
(B-17-02) 10DBC	571591	55	BUENELL W JOHNSON	1/5/1999	255	7	250	—	—	1/5/1999	150	—	DOM	X	—
(B-17-02) 10DBC	587775	55	JUSTIN & DEBRA WHITE	8/17/2001	300	6	300	—	—	8/17/2001	110	—	DOM	X	—
(B-18-02) 32AAA	544666	55	HENRY, CECIL R	12/29/1994	235	7	235	—	—	12/29/1994	130	—	DOM	X	—
(B-18-02) 32AAA	544667	55	ERIC HASLEY	9/1/1994	235	7	215	—	—	9/1/1994	120	—	DOM	X	—
(B-18-02) 32AAA	544669	55	THRAPP, RICHARD	11/21/1994	260	7	250	—	—	11/21/1994	120	—	DOM	X	—
(B-18-02) 32AAA	544670	55	DANNY & BARBARA CAMPANO	9/1/1994	236	7	180	—	—	9/1/1994	120	—	DOM	X	—
(B-18-02) 32AAA	544671	55	TERRY S & WILLIAM F TROUP	9/6/1994	236	7	236	—	—	9/6/1994	120	—	DOM	X	—
(B-18-02) 32AAA	570279	55	ELIZABETH M BOHL	8/18/1998	300	7	300	—	—	—	—	—	DOM	X	—
(B-18-02) 32AAA	596620	55	BRYAN HOEY	10/8/2002	310	6	302	—	—	10/8/2002	200	10	DOM	X	—
(B-18-02) 32AAB	544672	55	MCNUTT, SUE	10/27/1994	216	7	216	—	—	10/27/1994	110	18	DOM	X	—
(B-18-02) 32AAB	544715	55	DANA DORE	10/28/1994	235	7	235	—	—	10/28/1994	120	—	DOM	X	—
(B-18-02) 32AAB	544717	55	TREMBLAY, LEO	—	236	7	236	—	—	—	120	10	DOM	X	—
(B-18-02) 32AAB	578783	55	WILLIAM R DALTON	4/13/2000	280	6	280	—	—	—	—	—	DOM	X	—
(B-18-02) 32AAC	582975	55	DENNIS L BARTELS	12/14/2000	305	6	305	—	—	12/14/2000	139	—	DOM	X	—
(B-18-02) 32AAC	583716	55	LARRY LANE	11/14/2000	280	6	280	—	—	—	—	—	DOM	X	—
(B-18-02) 32AAD	561366	55	COX, ELBERT	3/12/1997	280	7	280	—	—	3/12/1997	180	—	DOM	X	—
(B-18-02) 32ABA	544714	55	STEPHEN G LEE	10/6/1994	236	7	236	—	—	10/6/1994	125	10	DOM	X	—
(B-18-02) 32ABA	586523	55	EDWARD & VALLERY ARTUP	5/10/2001	280	6	280	—	—	—	—	—	DOM	X	—
(B-18-02) 32ABA	593056	55	RICHARD & BONNIE RONDLETT	6/25/2002	290	6	290	—	—	6/25/2002	129	—	DOM	X	—
(B-18-02) 32ABC	538778	55	ROD BRUENS	4/19/1993	230	7	230	—	—	4/19/1993	140	—	DOM	X	—
(B-18-02) 32ABC	543647	55	CASE & ANGELA STAMY	6/6/1994	230	7	230	—	—	6/6/1994	139	—	DOM	X	—
(B-18-02) 32ABD	202075	55	JOHN N BASSETT	—	240	6	240	—	—	—	142	—	DOM	X	—
(B-18-02) 32ABD	563816	55	CHRISTOPHER BARTELS	8/8/1997	240	7	240	—	—	8/8/1997	100	—	DOM, IRR	X	—
(B-18-02) 32ADA	517746	55	KELLY/ROBERT HERREBAMILLER	7/6/1997	220	7	220	—	—	7/6/1997	146	34	DOM	X	—
(B-18-02) 32ADA	562049	55	TISCHLER, DWAYNE	6/3/1997	240	7	240	—	—	—	—	—	DOM	X	—
(B-18-02) 32ADA	562051	55	TISCHLER, DWAYNE	6/2/1997	240	7	240	—	—	—	—	—	DOM	X	—
(B-18-02) 32ADA	563907	55	MICHAEL & SHARON PIERCE	8/8/1997	240	7	240	—	—	8/8/1997	100	—	DOM	X	—
(B-18-02) 32ADB	576046	55	MIKE KAMINSKI	8/13/1999	260	4	260	—	—	—	—	—	DOM	X	—
(B-18-02) 32ADB	576350	55	JOHN KAMINSKI	8/18/1999	260	4	260	—	—	—	—	—	DOM	X	—
(B-18-02) 32ADC	509765	55	DUNBAR STONE CO INC.	8/3/1994	205	7	205	—	—	8/3/1994	120	35	DOM	X	—
(B-18-02) 32ADD	505340	55	LESLIE & JOANNA ROBERTS	6/24/1983	205	7	205	—	—	6/24/1983	160	30	DOM	X	—
(B-18-02) 32ADD	549798	55	MARCUS PETROPOULOS	5/25/1995	255	7	255	—	—	5/25/1995	130	—	DOM, IRR	X	—
(B-18-02) 32BAA	201826	55	MYRNA ELIZABETH BREASHEARS	12/29/2003	245	—	245	—	—	12/29/2003	130	10	DOM	X	—

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						DIAM. (inches)	DEPTH (ft, bls)[b]	PERF. (ft, bls)		DATE	DEPTH (feet)				
(B-18-02) 32BAA	202266	55	JOHN L RAMAGE	2/11/2004	303	6	303	—	—	2/11/2004	135	10	DOM	X	—
(B-18-02) 32BAA	541609	55	MARVIN G MARTIN	1/7/1994	225	7	225	—	—	1/7/1994	130	12	IRR, DOM	X	—
(B-18-02) 32BAA	555969	55	RUTHANN LEE	4/22/1996	215	7	215	—	—	4/22/1996	145	10	DOM	X	—
(B-18-02) 32BAA	555970	55	DICK AUSTIN	4/19/1996	215	7	215	—	—	4/19/1996	145	—	DOM	X	—
(B-18-02) 32BAA	557760	55	PAUL HURLEY	6/5/1996	195	7	195	—	—	6/5/1996	140	—	DOM	X	—
(B-18-02) 32BAA	566930	55	RONALD CHAPMAN	2/23/1999	220	7	220	—	—	2/23/1999	100	10	DOM	X	—
(B-18-02) 32BAA	570965	55	RAYMOND & JUDY STROM	11/16/1998	265	7	265	—	—	11/16/1998	128	—	DOM	X	—
(B-18-02) 32BAA	591897	55	KENNETH & ELEANOR MILLS	4/26/2002	360	6	360	—	—	4/26/2002	140	—	DOM	X	—
(B-18-02) 32BAB	511933	55	MARTIN,G	1/30/1986	195	7	195	—	—	1/30/1986	120	2	DOM	X	—
(B-18-02) 32BAB	543279	55	MARTIN, GARY,E	4/18/1994	215	7	215	—	—	4/18/1994	120	20	IRR, DOM	X	—
(B-18-02) 32BAB	559765	55	RUSSELL A FEDERICO	9/10/1996	215	7	215	—	—	9/10/1996	110	12	DOM	X	—
(B-18-02) 32BAB	561532	55	RICK KUCERA	3/21/1997	275	7	260	—	—	3/21/1997	170	10	DOM	X	—
(B-18-02) 32BAB	573868	55	HELEN FROST	4/13/1999	250	5	250	—	—	4/13/1999	150	—	DOM	X	—
(B-18-02) 32BAD	202439	55	KENNETH MITCHELL	3/22/2004	220	5	220	—	—	3/22/2004	142	—	DOM	X	—
(B-18-02) 32BAD	516233	55	JOHN C & ANDREA RAGLAND	6/22/1987	215	7	215	—	—	6/22/1987	140	10	DOM	X	—
(B-18-02) 32BAD	531614	55	FINK, BIANCE,	5/15/1991	195	—	—	—	—	5/15/1991	115	13	DOM, IRR	X	—
(B-18-02) 32BAD	567958	55	CYNTHIA STEVENS	8/7/1998	300	7	290	—	—	8/7/1998	142	—	DOM	X	—
(B-18-02) 32BBB	—	GWSI	—	8/1/1958	528	20	0-39	—	4393	4/29/2004	129.1	—	U	X	—
(B-18-02) 32BBC	546720	55	JO ANNE LEAVITT	10/24/1994	250	7	250	—	—	10/24/1994	86	10	DOM	X	—
(B-18-02) 32BBC	609265	55	KEVIN SCOTT	—	480	20	60	—	—	—	153	3000	IRR	—	—
(B-18-02) 32BBD	554044	55	CARLOS & EOLA VILLANUEVA	3/13/1996	215	7	215	—	—	—	—	19	DOM	X	—
(B-18-02) 32BCA	585519	55	JOHN A RHOADES	10/19/2001	280	6	280	—	—	10/19/2001	114	—	DOM	X	—
(B-18-02) 32BCB	552796	55	JOHN A RHOADES	3/21/1996	280	7	280	—	—	3/21/1996	150	—	DOM	X	—
(B-18-02) 32BCC	564110	55	NORRIES E (NED) LEIGH	1/2/1998	230	4	220	—	—	1/2/1998	120	—	DOM	X	—
(B-18-02) 32BCC	584637	55	SALVADOR SANCHEZ	12/21/2000	305	5	305	—	—	12/21/2000	121	—	DOM	X	—
(B-18-02) 32BCD	584113	55	JOHN A RHOADES	—	—	—	—	—	—	—	—	—	DOM	—	—
(B-18-02) 32BDD	576129	55	JACK FLETCHER	12/3/1999	275	4	27	—	—	12/3/1999	110	—	DOM	X	—
(B-18-02) 32CBA	572540	55	STEVE KNIGHT	1/21/1999	290	5	290	—	—	1/21/1999	170	—	—	X	—
(B-18-02) 32CCB	534361	55	FARLEE, WAYNE,	2/9/1992	280	7	280	—	—	2/9/1992	170	18	DOM, REC	X	—
(B-18-02) 32CCC	549743	55	MUNSON, WAYNE,	9/7/1995	235	7	235	—	—	9/7/1995	90	—	DOM, IRR	X	—
(B-18-02) 32CCC	552339	55	LUCERO, BRENDA,	10/13/1995	235	7	235	—	—	10/13/1995	90	—	DOM, IRR	X	—
(B-18-02) 32CCD	524118	55	TAMBRA TEMPLEMNA MORRIS	4/22/1989	255	7	255	—	—	4/22/1989	145	60	DOM	X	—
(B-18-02) 32CCD	586268	55	JOHN & BRENDA LUCERO	—	250	7	250	—	—	—	120	—	DOM	X	—
(B-18-02) 32CDA	513626	55	MEJIA, MANUEL,	10/6/1986	225	7	20	—	—	10/6/1986	132	34	DOM	X	—
(B-18-02) 32DAA	200173	55	RICHARD D CROWDER	—	300	5	300	—	—	—	123	—	DOM	X	—
(B-18-02) 32DAA	—	GWSI	—	—	—	18 12	—	—	4396	2/24/1999	136.67	—	U	—	—
(B-18-02) 32DAB	561357	55	BARNHART, RALPH,	6/10/1997	210	7	210	—	—	6/10/1997	170	—	DOM	X	—
(B-18-02) 32DBB	609269	55, GWSI	DUNBAR STONE CO INC.	—	280	12	20	—	4370	2/7/1992	112.6	600	IND	—	32DBC in 55
(B-18-02) 32DBD	533605	55	DUNBAR STONE CO INC.	12/5/1991	230	7	230	—	—	12/5/1991	117	—	DOM	X	—

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(B-18-02) 33ABB	563151	55	ARTHUR & VAL BARNES	12/1/1995	235	7	235	—	—	12/1/1995	140	14	DOM, IRR	X	—
(B-18-02) 33ABC	560849	55	ANTELOPE LAKES WATER	5/16/1997	260	6	246	—	—	5/16/1997	150	—	DOM	X	—
(B-18-02) 33ACA	95365	55	JESSE LEE PALMER	9/26/1980	220	6	220	—	—	9/26/1980	145	—	DOM	—	—
(B-18-02) 33BBA	537266	55	JAMES CLAVET	11/6/1992	345	7	345	—	—	11/6/1992	170	15	DOM	X	—
(B-18-02) 33BBB	591493	55	ROBERT SMITH	4/22/2002	280	6	278	—	—	4/22/2002	140	10	DOM	X	—
(B-18-02) 33BBC	547346	55	COLLEEN & BOB LOY	7/24/1995	240	7	240	—	—	—	—	—	DOM	X	—
(B-18-02) 33BBC	547347	55	JUNGLAS, RUTH	7/28/1995	235	7	235	—	—	—	—	—	DOM	X	—
(B-18-02) 33BBC	575956	55	DAVID M SANDERS	7/21/1999	243	4	243	—	—	7/21/1999	140	—	DOM	X	—
(B-18-02) 33BBD	546944	55	HARRY JAMES DEAN	1/2/1995	225	7	225	—	—	1/2/1995	120	35	DOM	X	—
(B-18-02) 33BBD	546945	55	ROBERT DURAN	1/3/1995	225	7	225	—	—	1/3/1995	120	—	DOM	X	—
(B-18-02) 33BCB	566500	55	BILL AND HELEN SPOKES	5/21/1998	260	7	260	—	—	5/21/1998	6	—	DOM	X	—
(B-18-02) 33CAD	624558	55, 35	WANBINGTON,M O	9/1/1979	260	6	7-245	—	—	9/1/1979	180	25	DOM	X	35-59217
(B-18-02) 33CCC	507636	55	SMITH,M B	6/19/1984	300	6	20	—	—	6/19/1984	180	—	DOM	X	—
(B-18-02) 34AAA	635250	55, GWSI	WEEKES, FELTON A	1/1/1939	3010	10	—	—	4490	2/8/1992	228.1	35	S	X	—
(B-18-02) 34ABA	570426	55	DEBORAH JEFFERY	10/7/1998	305	7	305	—	—	10/7/1998	200	—	DOM	X	—
(B-18-02) 34ABB	567870	55	MIKE JEFFERY	4/23/1998	280	7	280	—	—	4/23/1998	160	—	DOM	X	—
(B-18-02) 34ABC	563817	55	WILLIAM W BATTS III	8/29/1997	310	7	310	—	—	8/29/1997	190	18	DOM	X	—
(B-18-02) 34ABC	566075	55	JAMES AND DORIS MENEREY	4/22/1998	360	7	20	—	—	4/22/1998	140	—	DOM	X	—
(B-18-02) 34ABC	588953	55	SAM LUTEN	6/4/2001	261	6	261	—	—	6/4/2001	191	—	DOM	X	—
(B-18-02) 34ABC	589828	55	CONSTANCE CONTIRERAS	10/18/2001	300	6	300	—	—	10/18/2001	190	—	DOM	X	—
(B-18-02) 34ACB	584894	55	GEORGE EDWARDS	—	292	7	280	—	—	—	185	18	DOM	X	—
(B-18-02) 34ACC	565407	55	REED HASLER	6/22/1998	305	7	300	—	—	6/22/1998	190	—	DOM	X	—
(B-18-02) 34ACC	—	35	C. L. RECKER	1/1/1980	280	6	7-20	—	—	—	—	55	DOM	X	35-84301
(B-18-02) 34ADA	586529	55	DEAN WAYSON HEADWATERS RANCH ASSOC LTD	—	330	7	230	—	—	—	230	—	DOM	X	—
(B-18-02) 34ADB	589810	55	JOYCE LAHTI	11/30/2001	320	6	307	—	—	11/30/2001	228	10	DOM	X	—
(B-18-02) 34BAB	545773	55	JESSE G DIXON	10/21/1994	275	7	100	—	—	—	—	25	DOM	X	—
(B-18-02) 34BAB	545775	55	DAVE SAMUELSON	10/21/1994	275	7	275	—	—	10/21/1994	75	—	DOM	X	—
(B-18-02) 34BAB	568325	55	DONALD M JONES	5/15/1998	225	7	225	—	—	5/15/1998	180	15	DOM	X	—
(B-18-02) 34BAD	593360	55	YAVAPAI BAPTIST ASSOCIATION	—	305	6	298	—	—	—	190	—	DOM	X	—
(B-18-02) 34BBB	540089	55	JOSEPH CATALFAMO	9/30/1993	270	7	270	—	—	9/30/1993	180	—	DOM	X	—
(B-18-02) 34BCB	519272	55	RAY HUERTA	10/27/1987	267	7	267	—	—	10/27/1987	160	30	DOM, IRR	X	—
(B-18-02) 34BCB	570632	55	DAVE JOHNSON	10/22/1998	282	7	280	—	—	10/22/1998	155	—	DOM	X	—
(B-18-02) 34BCB	591123	55	NELSON & NANCY JANIGIAN	3/27/2002	300	6	295	—	—	3/27/2002	185	—	DOM	X	—
(B-18-02) 34BCC	503536	55	R ROGERS	7/30/1982	232	8	63	—	—	7/30/1982	150	—	IRR	X	—
(B-18-02) 34BCC	567468	55	KAREN GRAHAM	6/11/1998	275	7	375	—	—	6/11/1998	118	—	DOM	X	—
(B-18-02) 34BDA	519842	55	LEWIS E MOON	1/8/1989	255	7	240	—	—	1/8/1989	194	33	DOM	X	—
(B-18-02) 34BDA	546371	55	TANYA LIPTAK	11/17/1994	255	7	255	—	—	11/17/1994	175	—	DOM	X	—
(B-18-02) 34BDB	523938	55	CINDY BOOKER	3/9/1989	300	7	300	—	—	3/9/1989	170	20	DOM	X	—
(B-18-02) 34BDB	546037	55	VICENTE R AND HOLLY R GARCIA	10/20/1994	218	7	236	—	—	10/20/1994	181	—	DOM	X	—

134/01/Phase1_Report/WellInventory.xls/09Jul2008 Page 7 of 8 ERROL L. MONTGOMERY & ASSOCIATES, INC.

TABLE 1. WELL INVENTORY FOR VICINITY OF PROPOSED RECHARGE SITE NEAR PAULDEN, YAVAPAI COUNTY, ARIZONA

CADASTRAL LOCATION	ADWR 55-WELL REGISTRY NUMBER	DATA SOURCE[a]	OWNER	DATE COMPLETED	DEPTH DRILLED (feet)	CASING			ALTITUDE (ft, msl)[c]	WATER LEVEL		PUMPING RATE (gpm)[d]	WATER USE[e]	DRILLER'S LOG	REMARKS
						DIAM. (inches)	DEPTH (ft, bls)[b]	PERF. (ft, bls)		DATE	DEPTH (feet)				
(B-18-02) 34CCB	500129	55	STEPHEN & CAROL JONES	6/29/1981	200	6	32	—	—	6/29/1981	137	21	DOM	X	—
(B-18-02) 34CCB	608990	55	F R PEREZ	9/7/1984	244	7	240	—	—	9/7/1984	180	10	DOM	X	—
(B-18-02) 34CCD	571792	55	PAULDEN VOLUNTEER FIRE DEPT.	3/2/1999	320	5	320	—	—	3/2/1999	220	—	DOM	X	—
(B-18-02) 34CDC	616219	55	DOUGLAS RAY CLEM	3/20/1997	245	7	245	—	—	3/20/1997	136	10	DOM	X	—
(B-18-02) 34CDD	587778	55	DARLENE BRIGHT	8/22/2001	270	6	270	—	—	—	—	—	DOM	X	—
(B-18-02) 34DAA	589733	55	MARTIN & CYNTHIA GOFF	3/8/2002	320	5	320	—	—	—	—	15	DOM	X	—

[a] DATA SOURCE
55 = ADWR 55 Wells Registry Database
GWSI = ADWR Groundwater Site Inventory Database
35 = ADWR 35 Wells Registry Database

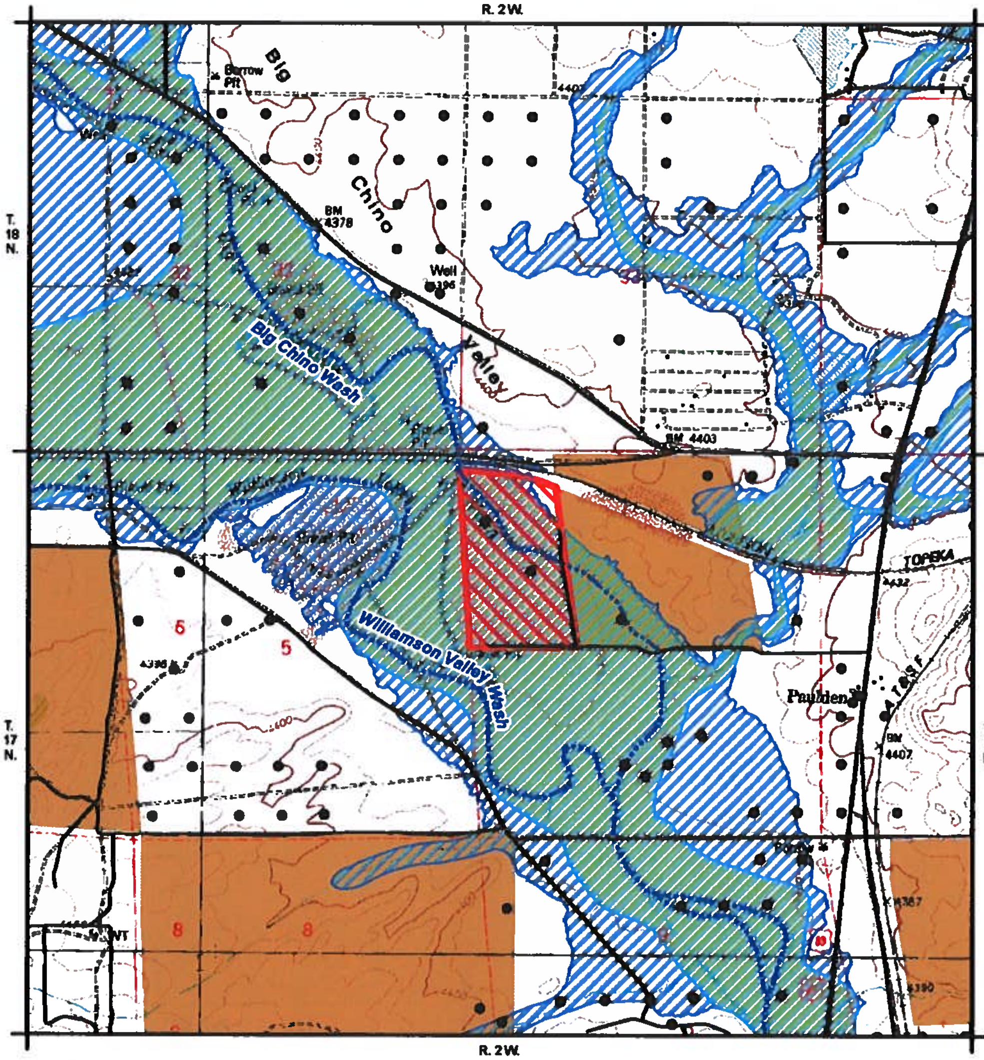
[b] ft, bls = feet below land surface

[c] ft, msl = feet above mean sea level

[d] gpm = gallons per minute

[e] WATER USE
COM = COMMERCIAL
DOM = DOMESTIC
IRR = IRRIGATION
PUB = PUBLIC SUPPLY
PROD = PRODUCTION
S = STOCK
T = TEST
U = UNUSED
MUN = MUNICIPAL
NONE = NONE
REC = RECREATION
IND = INDUSTRIAL

— = no data available



EXPLANATION

- Wells Listed in ADWR "55", "35", and GWSI Databases
- Roads
- Boundary of Proposed Recharge Site

General Land Ownership

- Private Land
- State Trust Land

Flood Zones

- Common Floodway
- 100-year Flood Hazard Area

N

0 1,000 2,000
Feet

FIGURE 1. LOCATION MAP FOR PROPOSED RECHARGE SITE

GIS-Tuc\134.01\Welloc_Land_RechargeBase\08July2008

ERROL L. MONTGOMERY & ASSOCIATES, INC.

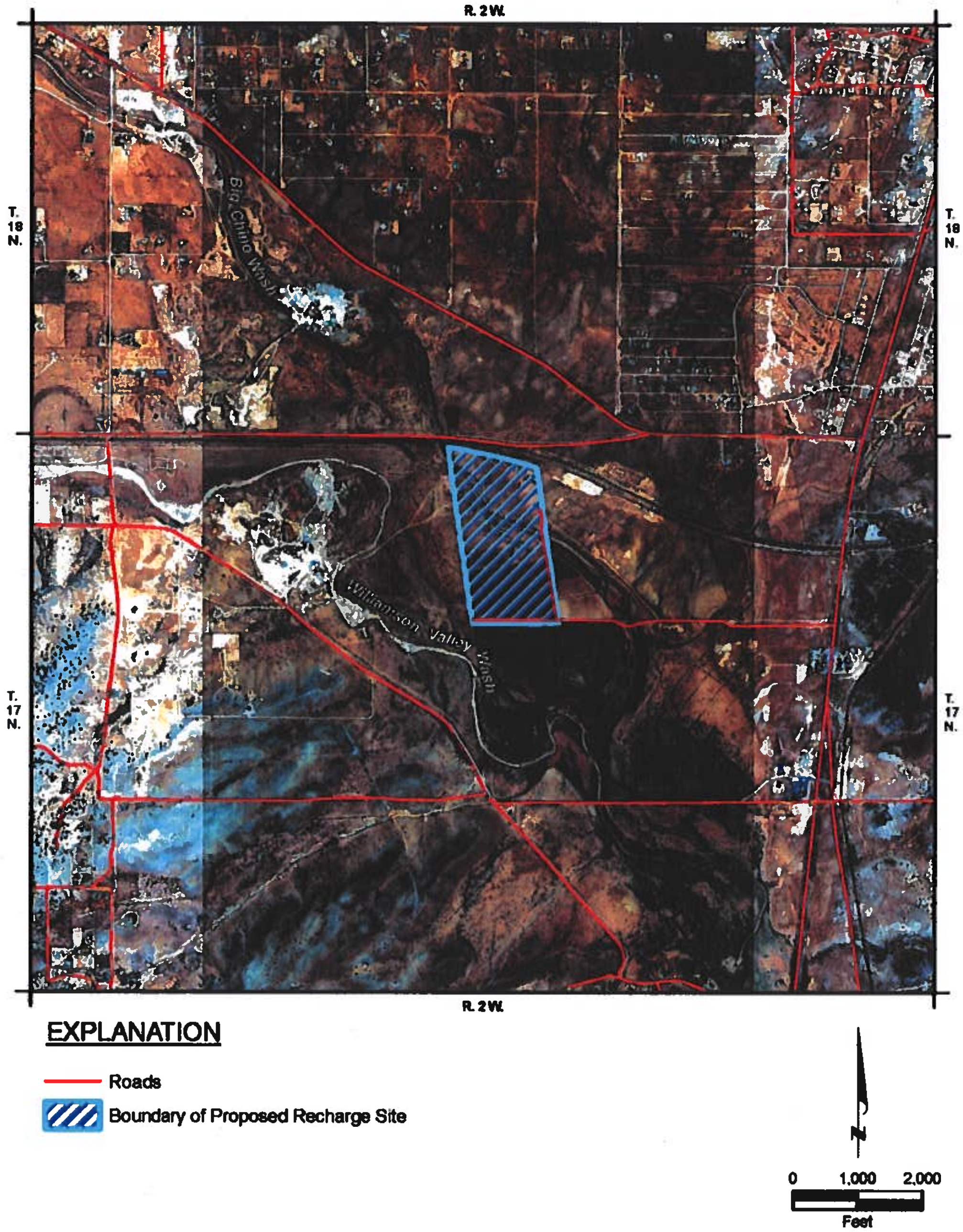
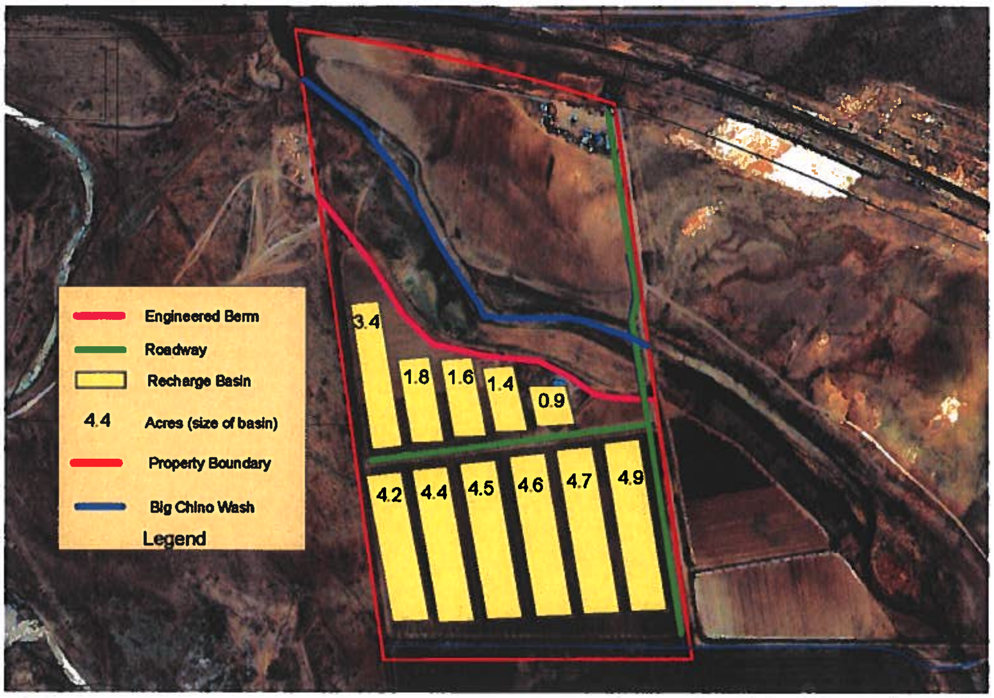


FIGURE 2. AERIAL PHOTOGRAPH FOR VICINITY OF PROPOSED RECHARGE SITE

ERROL L. MONTGOMERY & ASSOCIATES, INC.

GIS-Tuc\134.01\RechargeBase_aerial\08July2008



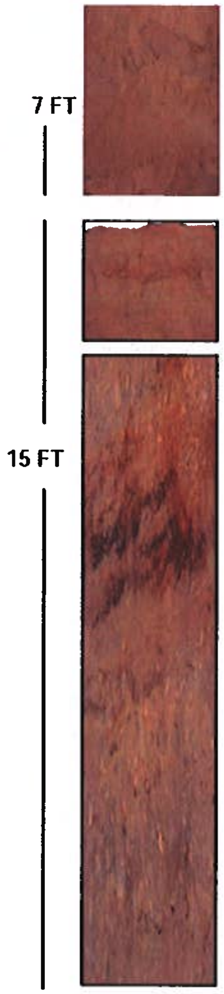
(Courtesy of Mark Holmes, Town of Chino Valley)

FIGURE 3. CONCEPTUAL LAYOUT OF INITIAL BASINS AT PROPOSED RECHARGE SITE

DRAFTING\134.01\RECHARGE SITE WORK 2.PDF 08July2008

APPENDIX A

DRILLERS' LOGS FOR WELLS IN VICINITY OF PROPOSED RECHARGE SITE AND PHOTOGRAPHS OF PIT WALL IN SAND AND GRAVEL MINE AT THE SITE



Top 7 feet of over burden were removed but consists of predominantly a Arenite consisting of mainly of a well-sorted coarse sand with some fine sand and medium to fine silts. Grains mainly sub-rounded to rounded. Sediments observed not in situ but stocked piled area. Matrix consisted of a pseudomatrix of finer grain sediments.

Top 3 feet of the outcrop consisted primarily of a moderately to well sorted Arenite, consisting of medium to coarse sand with some medium to coarse silt and a pseudomatrix of finer grained sediments. 7.5 YR 5/3

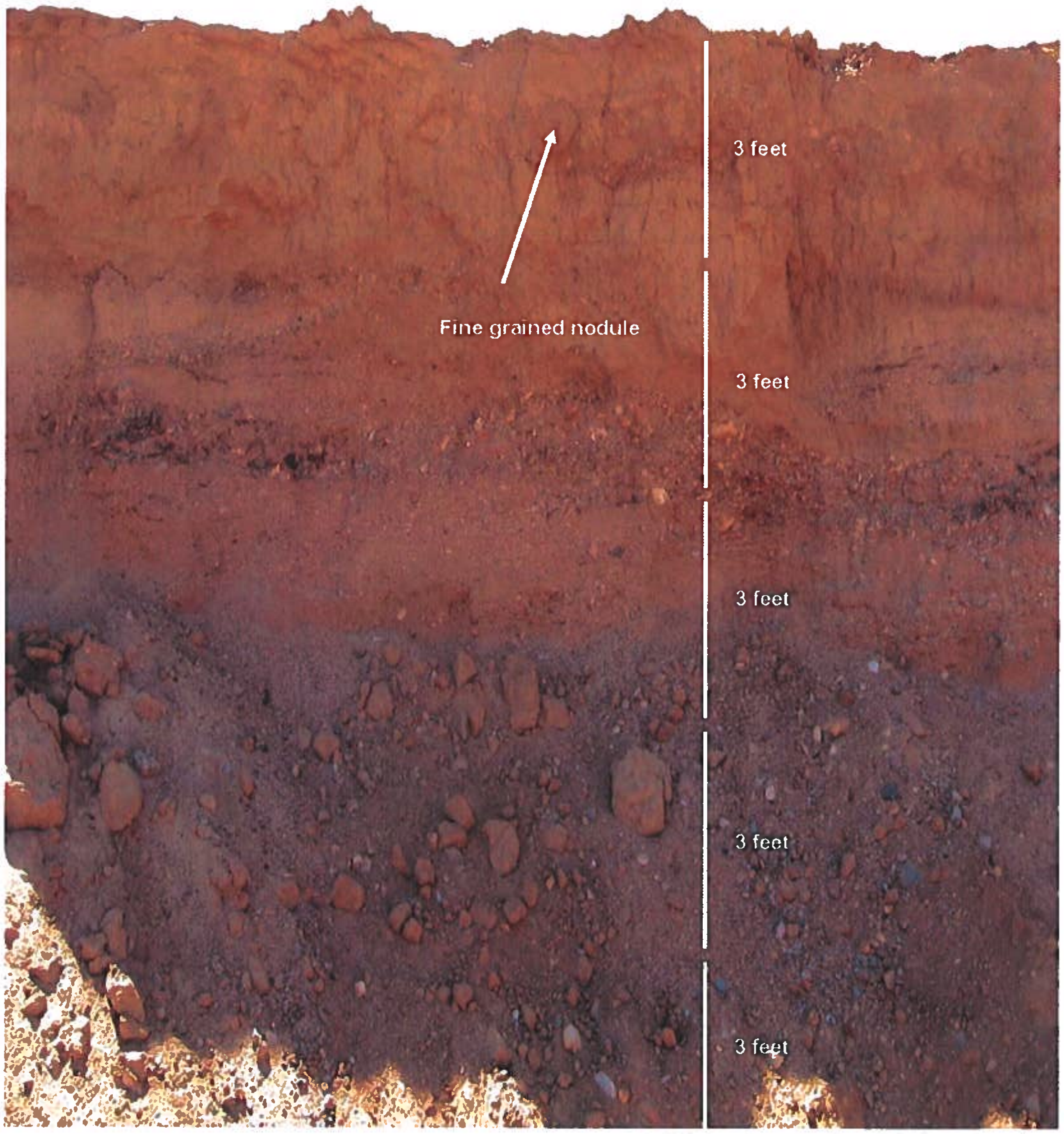
Next 12 feet depth of sediments consists of primarily of inter-bedded layers of predominant Rudite with small interbeding of Arenite. Rudite consists primarily of a sandy-gravel. Sand consisting of coarse sand, very coarse sand, Fine-pebble to coarse –pebble gravel. The outcrop had a predominant 7.5 YR 6/3 color (1994 Munsell). Small interbedded Arenite layers consisting of Fine to coarse sand sub-rounded to rounded. Moderately to very poorly sorted sediments. Clasts sub-rounded to rounded. Pseudomatrix of finer grain Sediments.

Cross beds present indicating deposition via high energy water with A provenance of adjacent mountain geology.

(Courtesy of Mark Holmes, Town of Chino Valley)

FIGURE A-1. PROFILE DESCRIPTION FOR PIT WALL IN SAND AND GRAVEL MINE, SOUTHWEST PART OF PROPOSED RECHARGE SITE

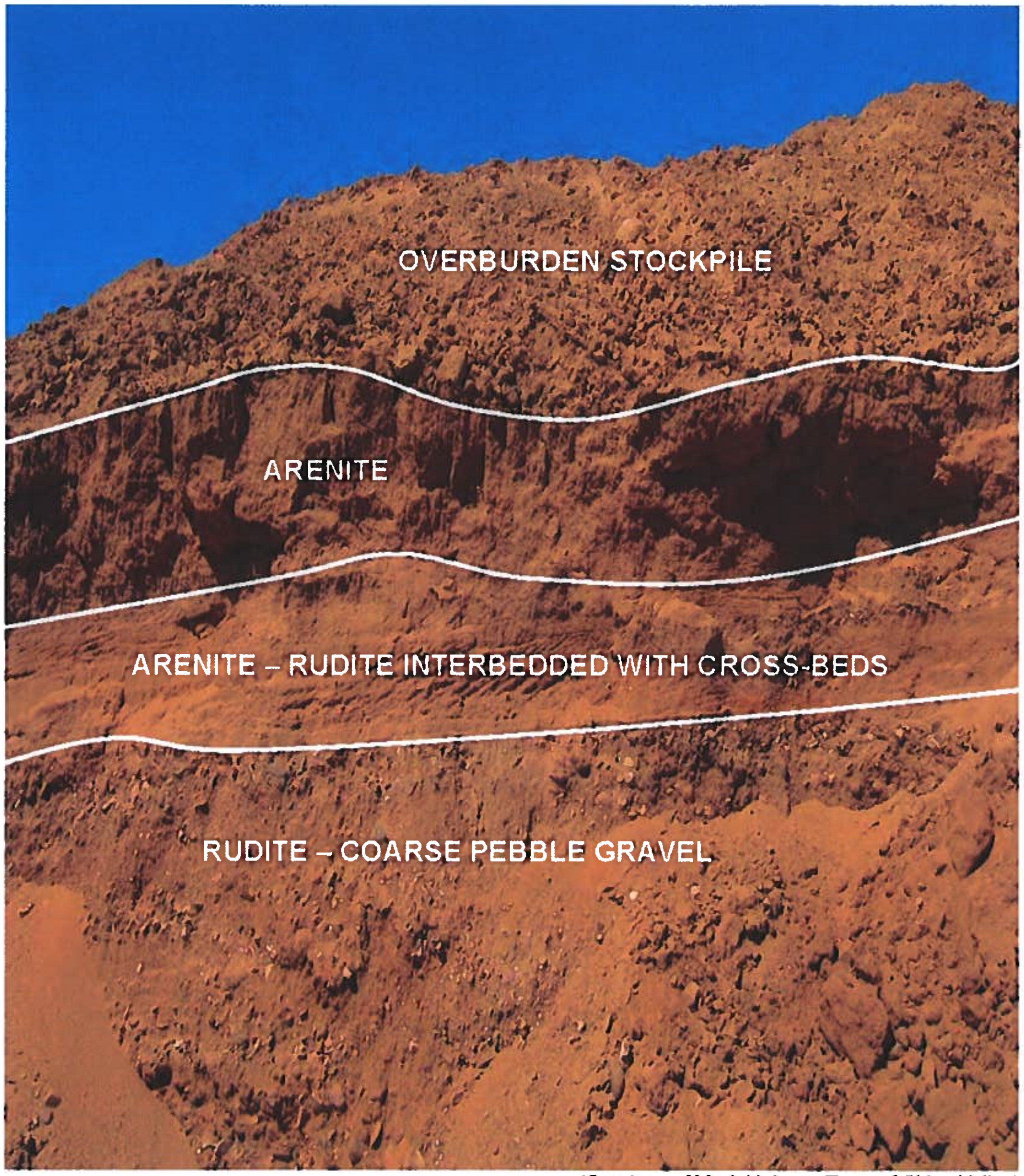
Photo 3. Looking East, showing entire outcrop



(Courtesy of Mark Holmes, Town of Chino Valley)

FIGURE A-2. PHOTOGRAPH OF EAST PIT WALL IN SAND AND GRAVEL MINE, SOUTHWEST PART OF PROPOSED RECHARGE SITE

Photo 5. Looking West, showing entire outcrop



(Courtesy of Mark Holmes, Town of Chino Valley)

FIGURE A-3. PHOTOGRAPH OF WEST PIT WALL IN SAND AND GRAVEL MINE, SOUTHWEST PART OF PROPOSED RECHARGE SITE