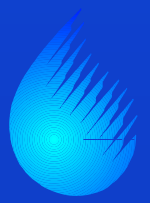
TWO DECADES OF ARTIFICIAL RECHARGE IN LAS VEGAS VALLEY: HOW FAR HAVE WE COME?

Las Vegas Valley Water District
and
Southern Nevada Water Authority
David J. Donovan

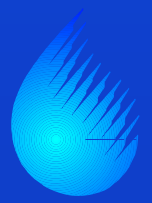
2010 Arizona Hydrological Society Symposium



Acknowledgments

- Current and previous staff of LVVWD and SNWA especially:
  - Bruce Wert
  - Joe Leising
  - Gavin Kistinger
  - Terry Katzer
  - Kay Brothers

note typo in abstract



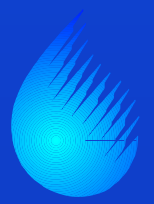
Purpose and Scope

- Examples of wells effected by climate variability inside Las Vegas Valley
- Summary of Las Vegas Valley Hydrology
- Examples of wells effected operational changes inside of Las Vegas Valley
- Monitoring, management, and planning

Artificial Recharge in Las Vegas Valley

- Artificial recharge (AR) is the process of designed (as opposed to natural) replenishment of groundwater storage through saturated or unsaturated geologic materials

- The Las Vegas Valley Water District has operated an AR aquifer recharge, storage, and recovery (production) program since 1987
  - Over 90 % was recharged though District Facilities

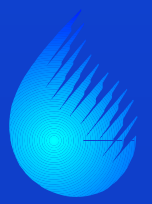


Nevada's Colorado River rights

- Nevada's consumptive use water right is 2 % of all water rights on Colorado River
- All rights = 16.5 Mafy
- Nevada = 0.3 Mafy (3.7×10^8 m^3)

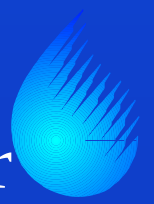
History (Late 20th Century and 2000's)

- Initial Investigations for Cooperative Water Project
- 1987 - - SNWS provides source water for Artificial Recharge (AR) in Las Vegas Valley
- Formation of SNWA
- Conservation Goals and Tiered Water Rate Structure
- Formation of Ground Water Management Program Survey
- Valley-wide Groundwater Level Monitoring
- Periodic and Ongoing Geochemical Studies



Water in the Las Vegas Valley

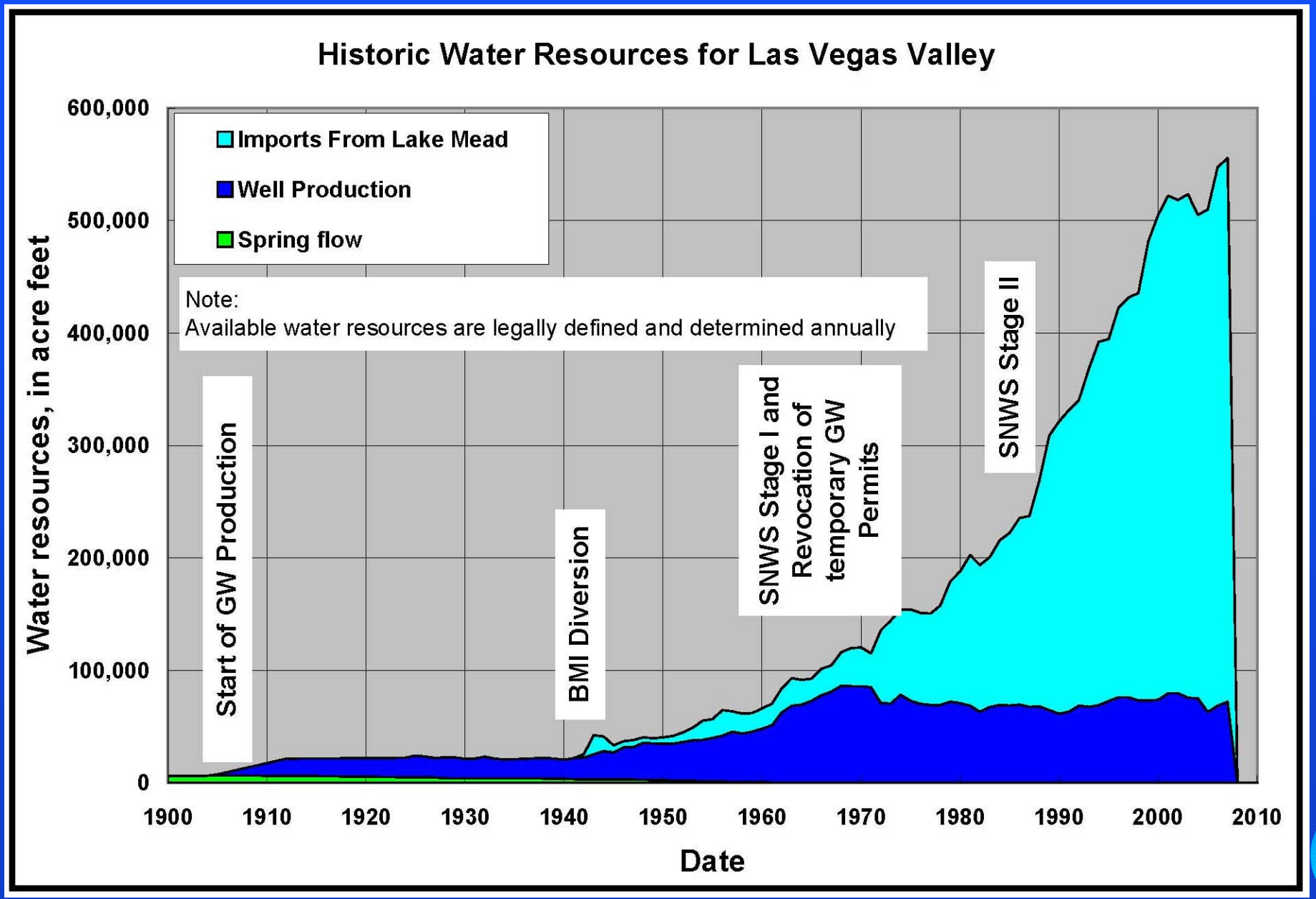
- Nevada is the driest state in the U. S. The L.V. Valley floor receives 10 cm average annual precipitation; mountain areas may receive 66 cm per year (snow)
- There are no natural rivers in the Las Vegas Valley
- Approx. 90% of water supply comes from Colorado River via Lake Mead
  - The Colorado River is shared by 7 States, 10 Native American Tribes and the Republic of Mexico
  - Nevada uses all of its 300,000 acre-feet consumptive use Colorado River water allocation
- Approx. 10% of water supply comes from groundwater



Water Resources Planning

- Described in SNWA Resource Plan Along With A History of Past Resources and Future Probable Resources

- http://www.snwa.com/html/wr_resource_plan.html

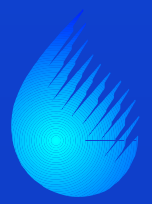

Historic Water Resources for Las Vegas Valley
Water resources, in acre feet
600,000
500,000
400,000
300,000
200,000
100,000
0
Imports From Lake Mead
Well Production
Spring flow
Note:
Available water resources are legally defined and determined annually
Start of GW Production
BMI Diversion
SNWS Stage I and Revocation of temporary GW Permits
SNWS Stage II
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Date

Las Vegas Valley Groundwater Hydrology

- A small percentage of total supply
- In the central part of the valley, water level changes are large and strongly associated with anthropogenic activities
- Water level changes, however, are ultimately controlled by long term natural recharge volumes and permeability differences
- Water level rises were observed prior to the initiation of artificial recharge activities

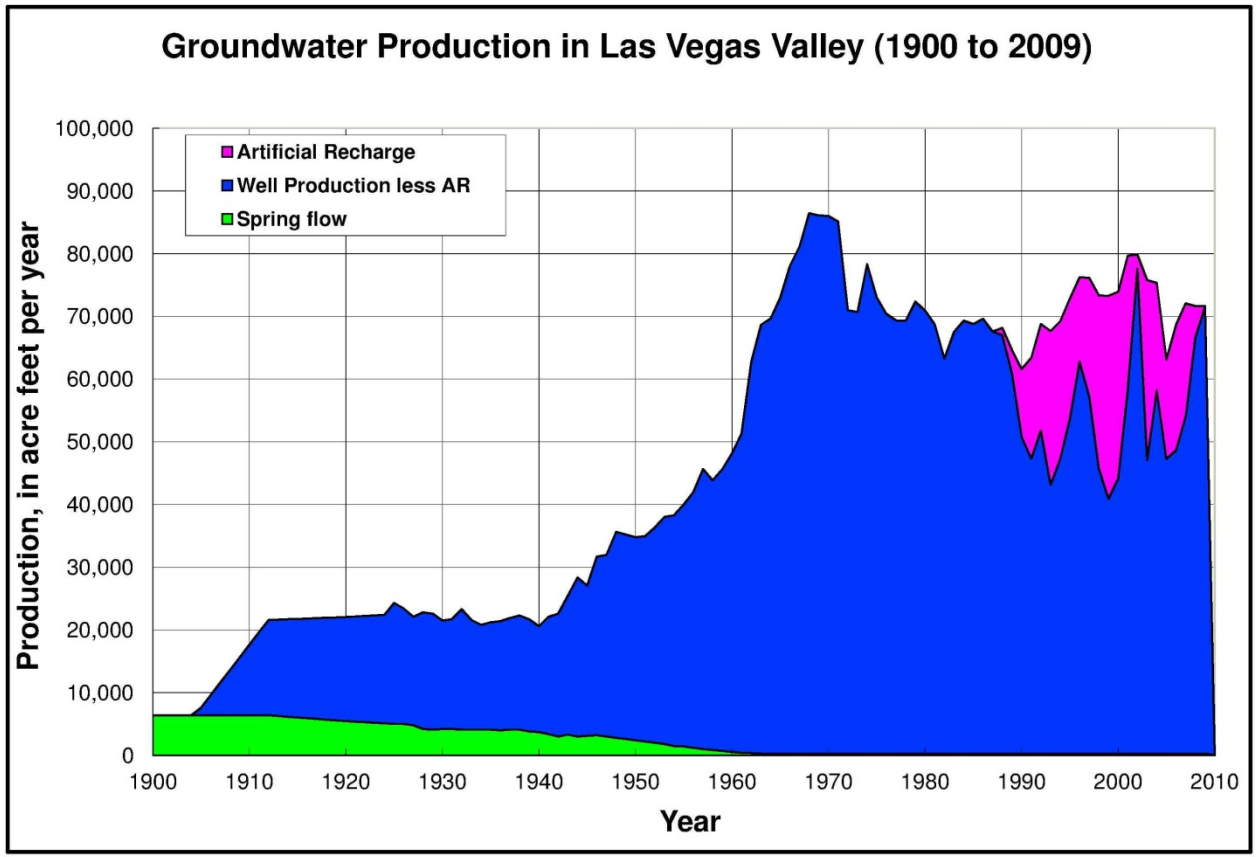
Las Vegas Hydrographic Basin

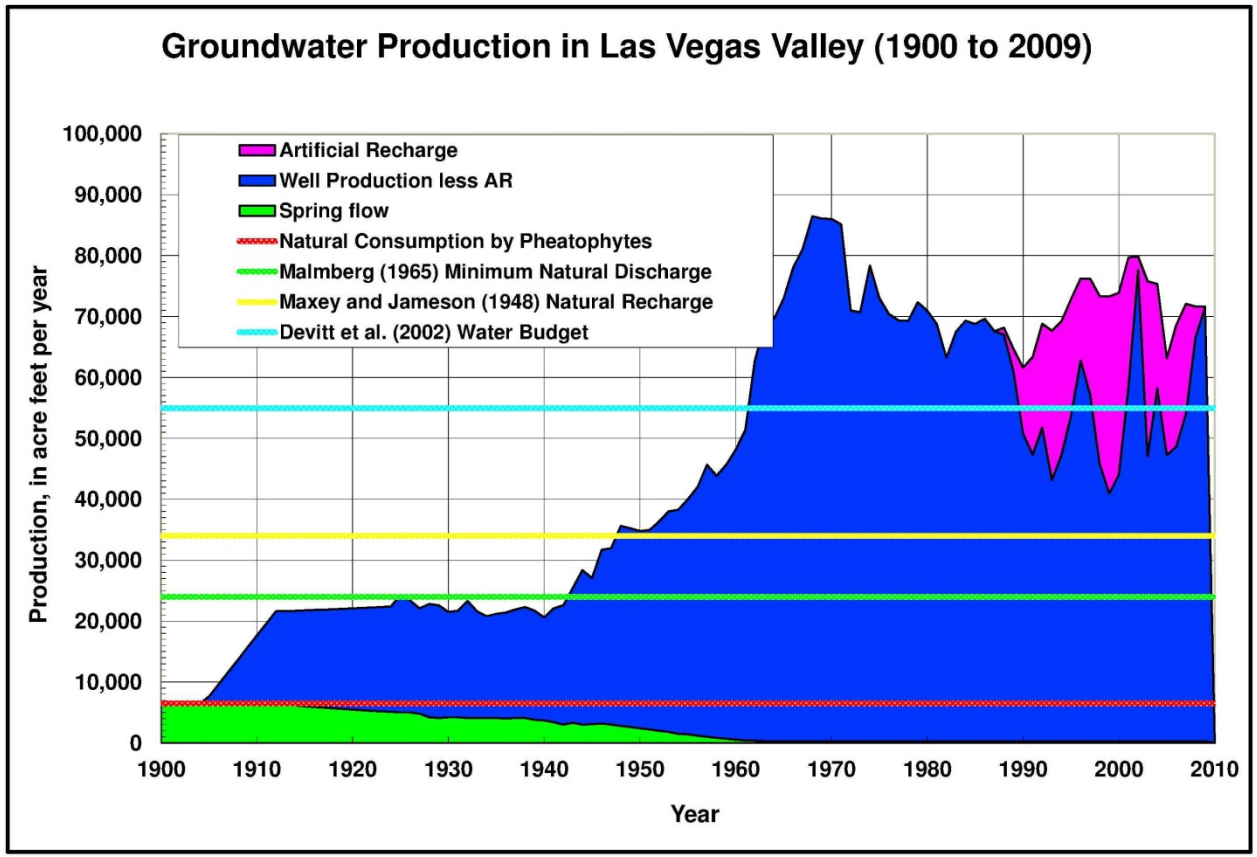
- 1500 miles^2 (3,885 km^2)
- Altitudes ranges from approximately 12,000 feet (3,650 m) to 1,500 feet (450 m) above sea level
- Structurally formed alluvial-filled basin
- Alluvium thick ranges from approximately 1,000 feet (300 m) to greater than 5,000 feet (1,525 m) thick
- Natural recharge to basin estimated to be at least 35,000 acre-feet (43×10^6 m^3) per year. Could be as much as 57,000 acre-feet (70×10^6 m^3) per year



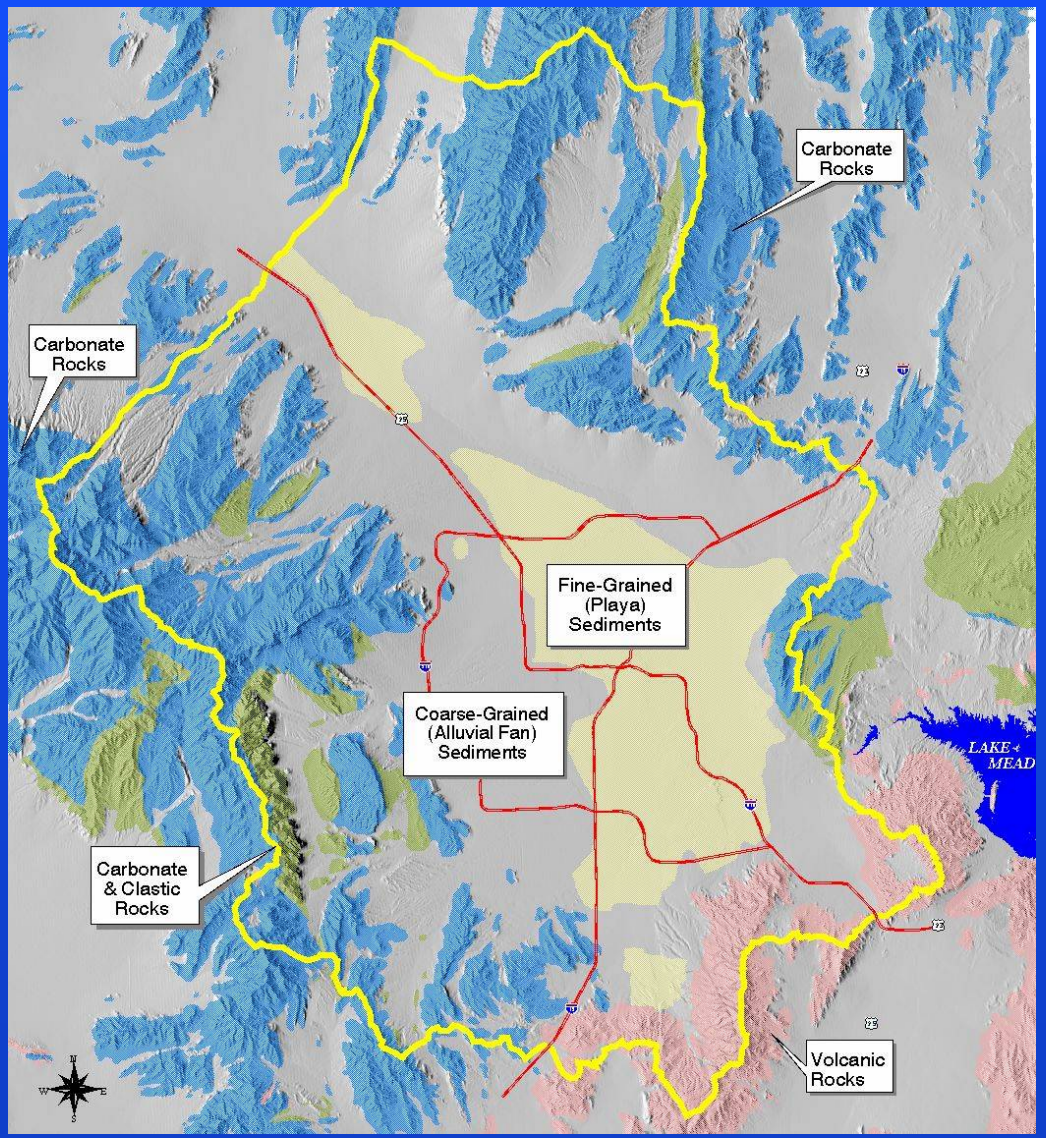
Las Vegas Hydrographic Basin

LVVWD (2004)


Groundwater Production in Las Vegas Valley (1900 to 2009)
Artificial Recharge
Well Production less AR
Spring flow
Production, in acre feet per year
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

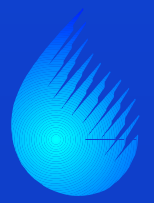

Groundwater Production in Las Vegas Valley (1900 to 2009)
Artificial Recharge
Well Production less AR
Spring flow
Natural Consumption by Pheatophytes
Malmberg (1965) Minimum Natural Discharge
Maxey and Jameson (1948) Natural Recharge
Devitt et al. (2002) Water Budget
Production, in acre feet per year
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

Generalized Geologic Map



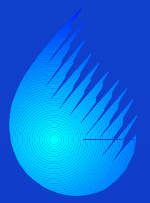
Operational Changes / Observations

- Long term shift in production (South)
- Long term reduction in production (N-Central)
- Intentional shift west (West-Central)
- New production areas and identification of production vs climate variation effects (North-West)
- Water level rises, in all cases, are better described as a response to natural recharge



Additional Observations

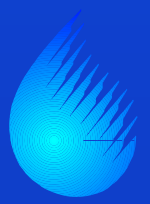
- Historical subsidence occurred offset of major production center
  - Partly controlled by geologic variations
- Current water level rise is largest at major production / AR center, however, more arealy extensive
  - Combination of reduced pumping stresses and natural recharge



Key Points

- Aquifer response (water levels changes) are primarily determined by the natural plumbing of the hydrogeological system (sources, sinks and flow paths).

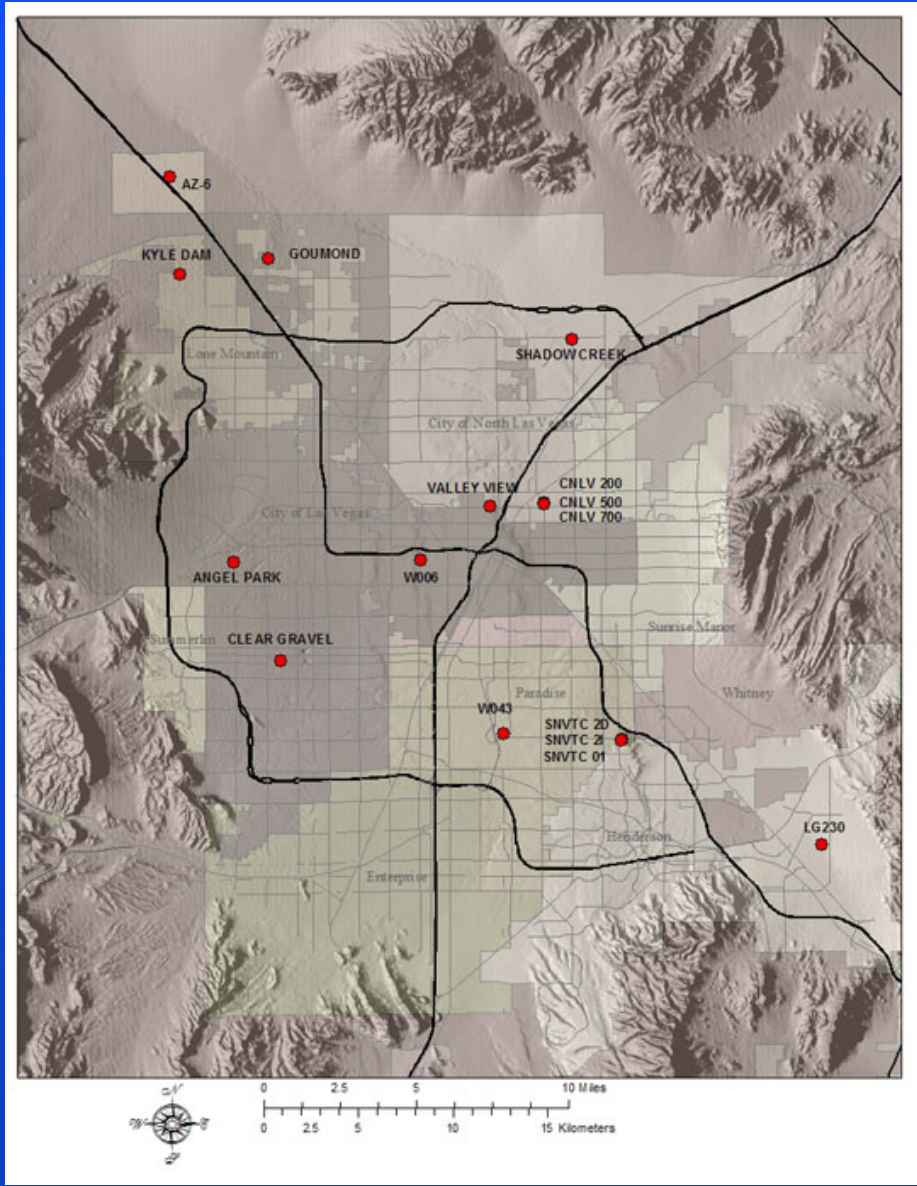
- The most accurate way to determine these factors is by careful analysis of the operational changes

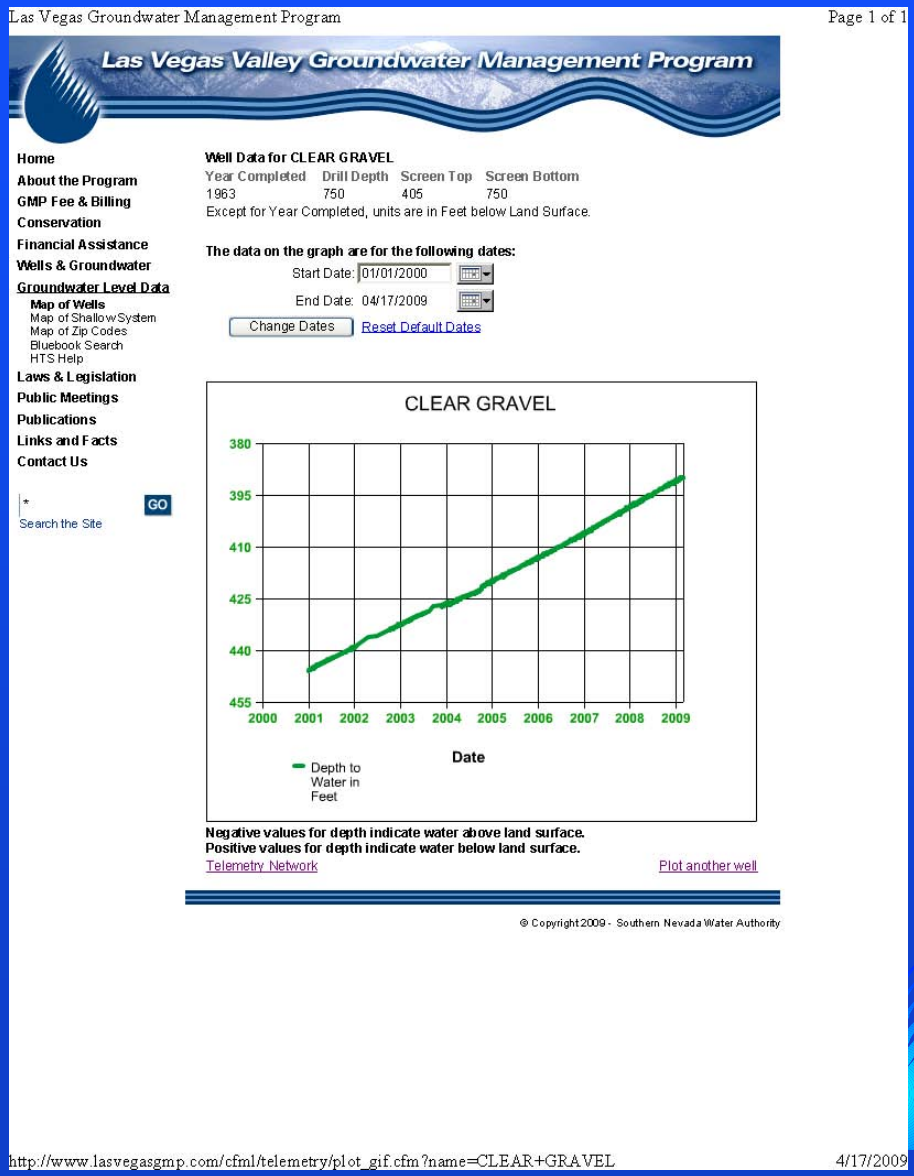


Implications

- AR has nearly the same effect as reduced production and In-Lieu recharge has been legally recognized, under specified conditions, since 2004

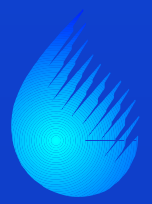
http://www.lasvegasgmp.com/html/telemetry_map.html





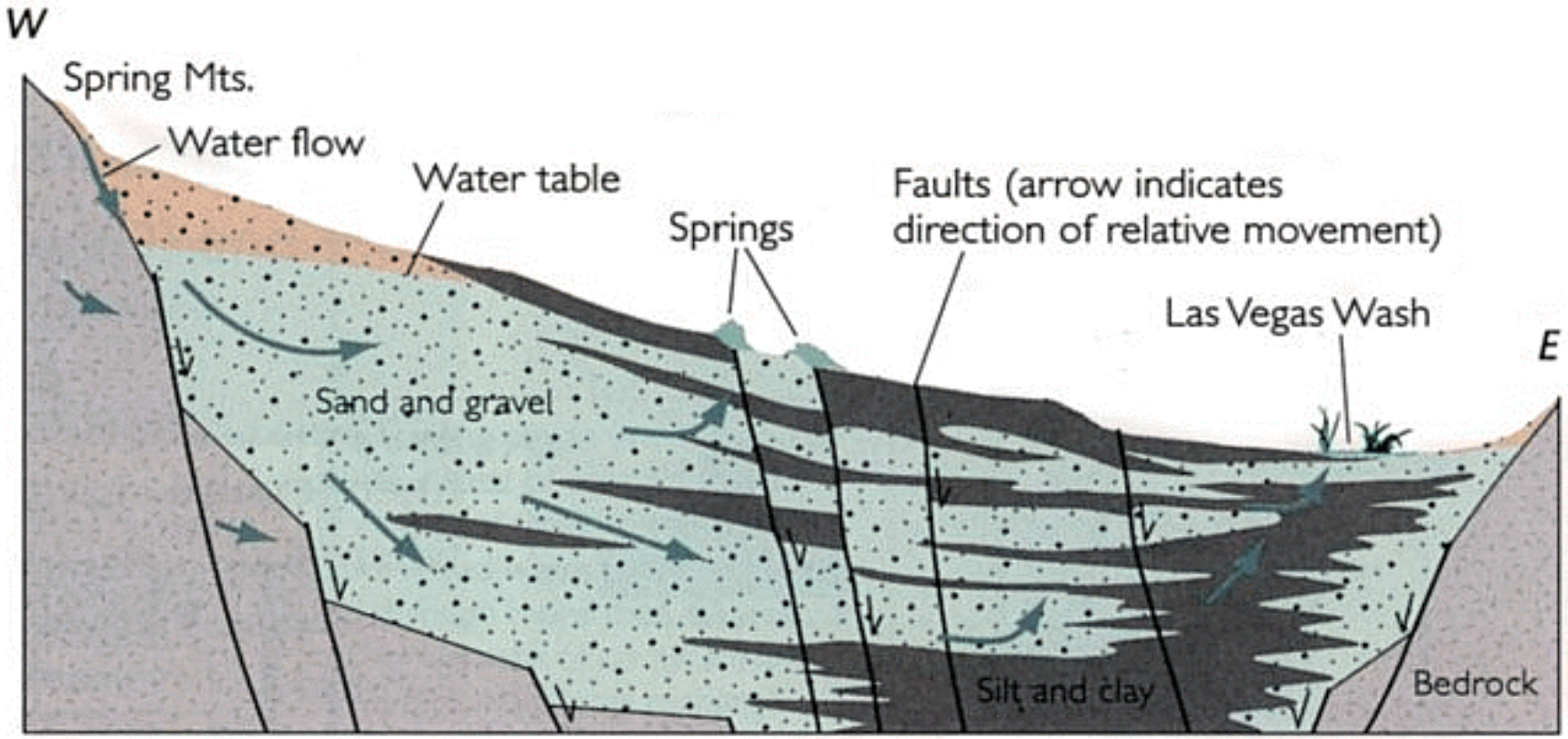
Las Vegas Hydrographic Basin

- 1500 miles^2 (3,885 km^2)
- Elevations range from 12,000 feet (3,658 m) to 1,500 feet (457 m) above sea level
- Structurally formed alluvial-filled basin
- Alluvial thickness from 0 feet (0 m) to ~ 15,000 feet (5,000 m) thick
- Natural recharge to the aquifer is estimated to be at least 35,000 acre-feet per year. The best estimate is about 50,000 acre-feet per year

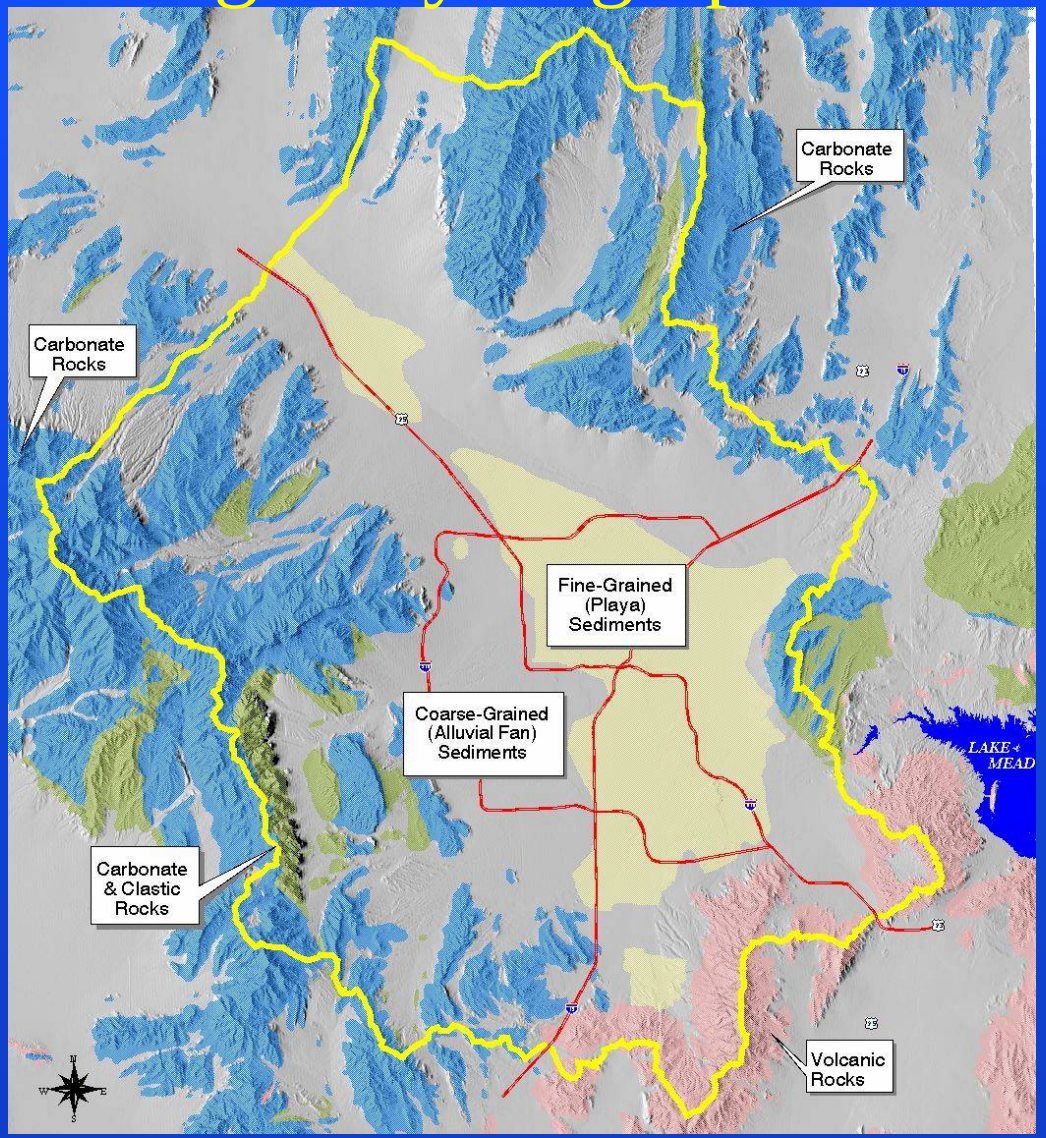


Las Vegas Hydrographic Basin

Las Vegas Valley Geologic Cross-Section

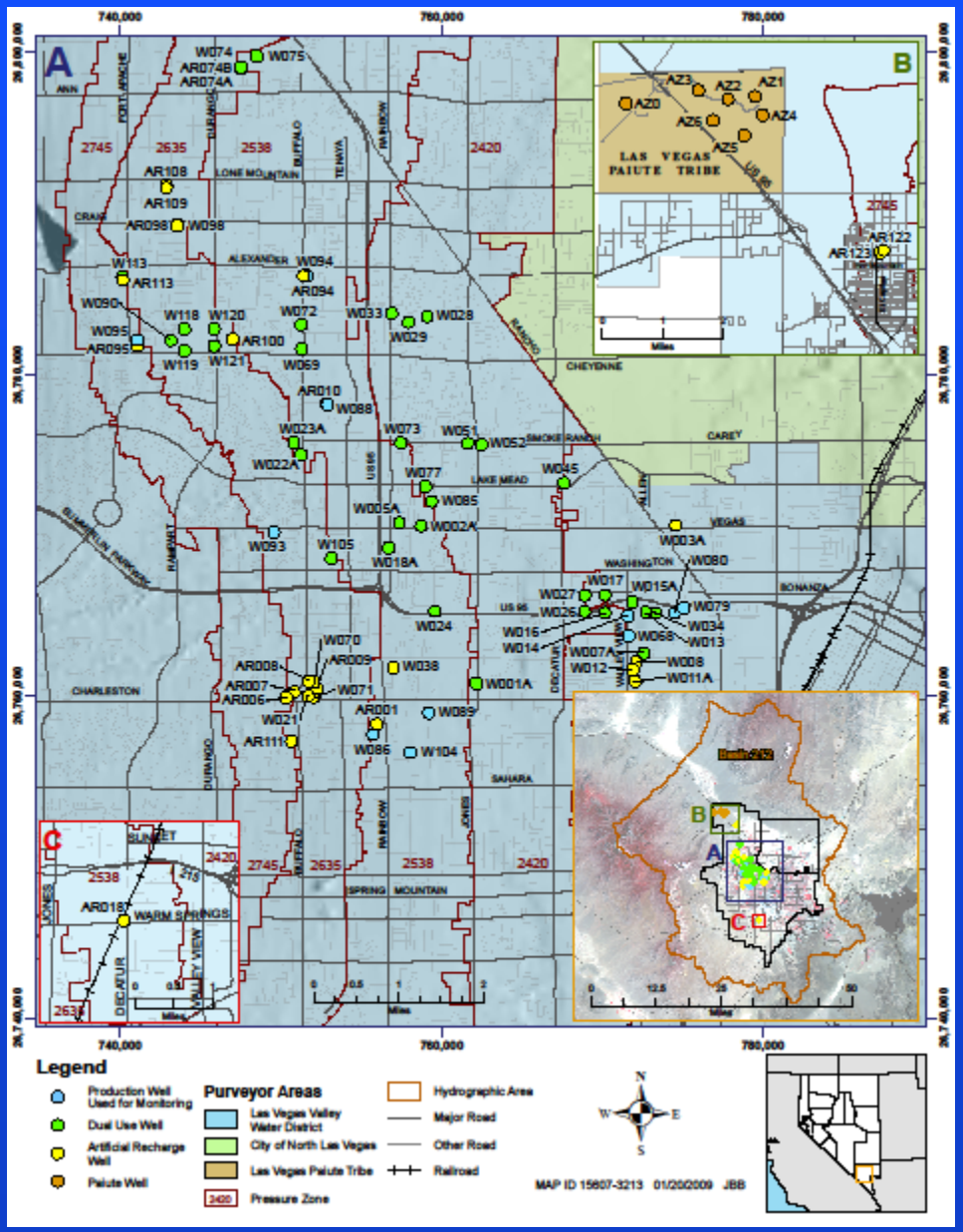


Generalized Surface Geologic Map of the Las Vegas Hydrographic Basin

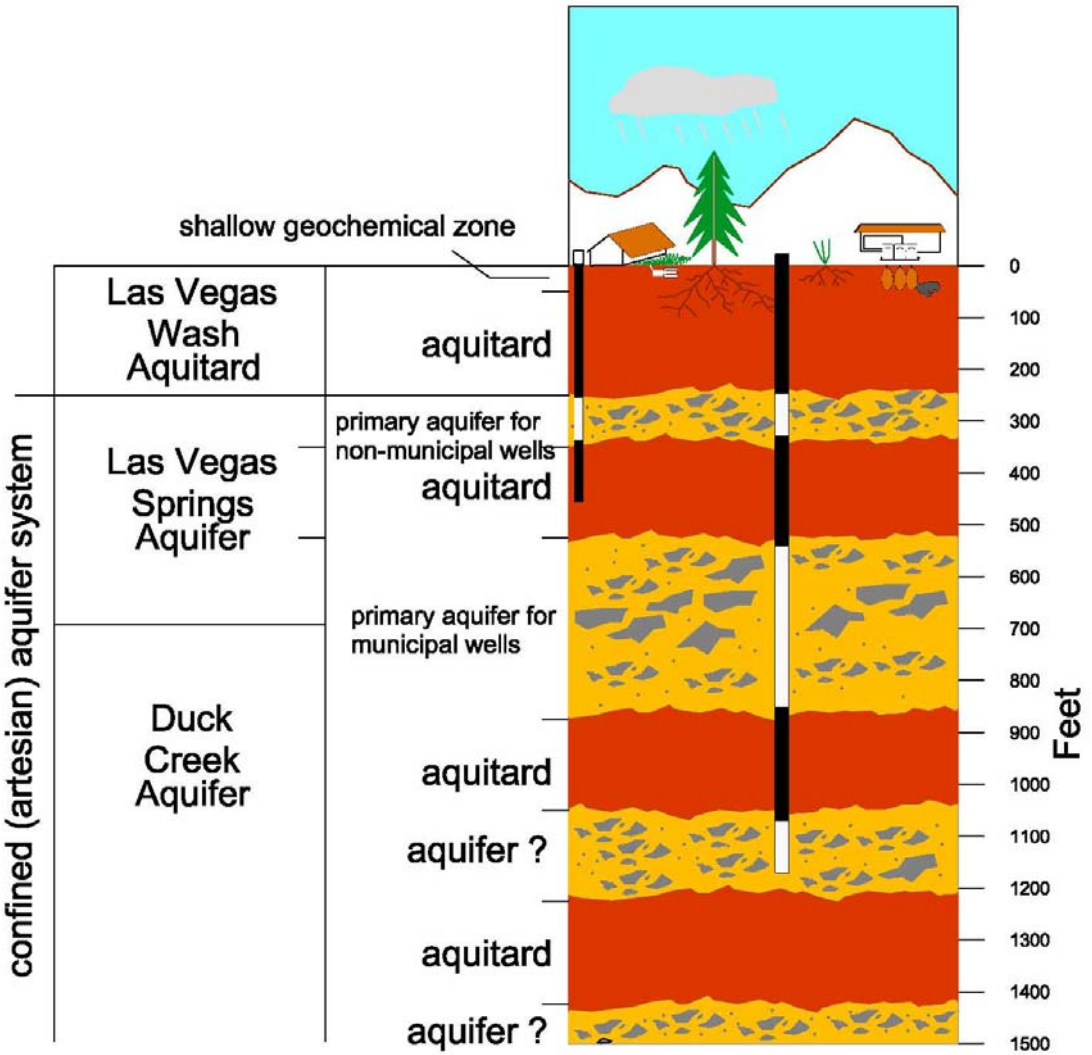


Location of LVVWD wells used for artificial recharge and groundwater production

- Dedicated AR Wells
- Dual Use Wells
- Production Wells



Very simplified diagram of the ground-water system in the central part of Las Vegas Valley



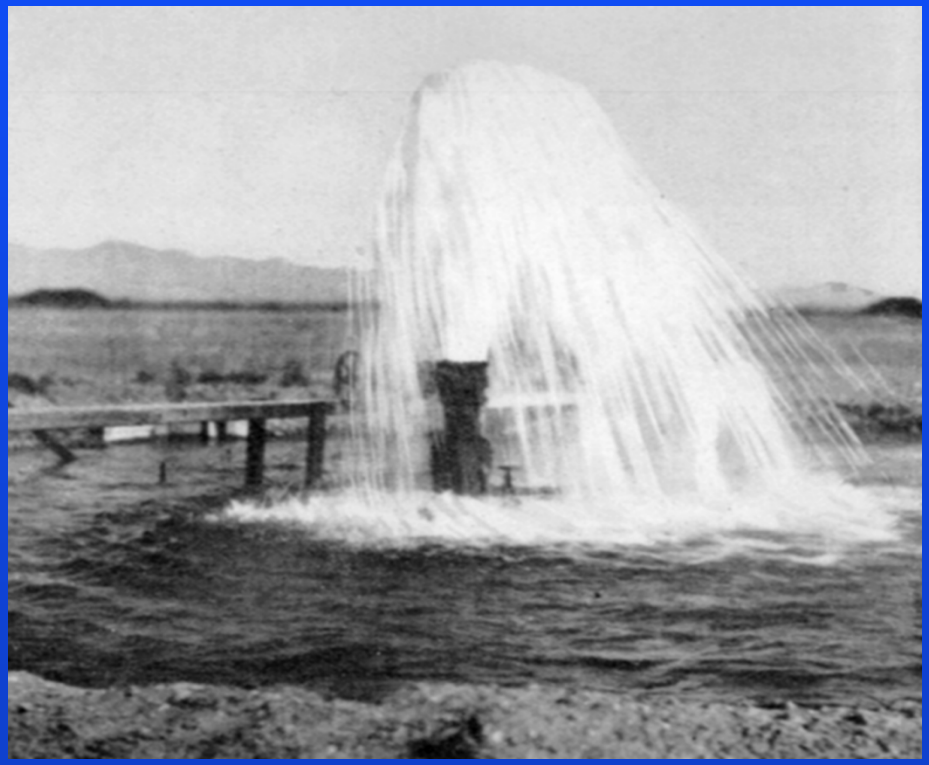
Primary Alluvial Aquifer

- Semi-consolidated interbedded sands and gravels
- Transmissivity between 6,000 to 300,000 gallons per day per foot
- Storativity between 10^{-4} to 10^{-8}
- Porosity between 10 to 20 percent
- Ground-water gradient from the northwest to the southeast
- Most productive zone from 200 to 750 feet (68 to 255 m) below land surface

LVVWD WELL #3 - - 1943

Artesian wells in the Las Vegas Valley

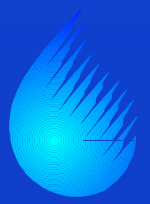
1912



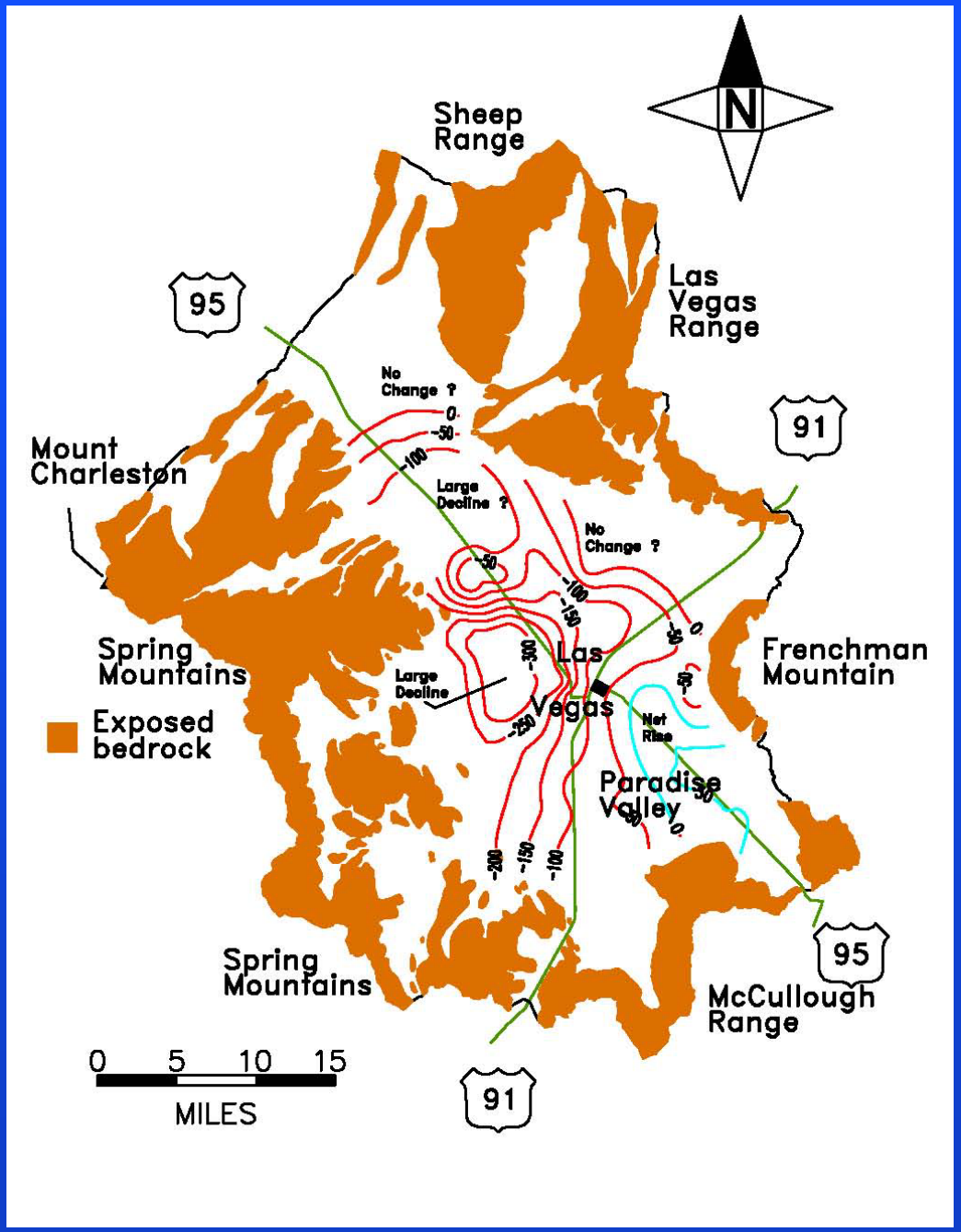
1998

Historical Water Level Changes

- Generally declining water levels prior to 1990
- Resulted in a large decline west of main well field (Location of Wells 1-17)
- Water levels after 1990 are rising in the same area as the historic decline
- Maps and hydrographs provided



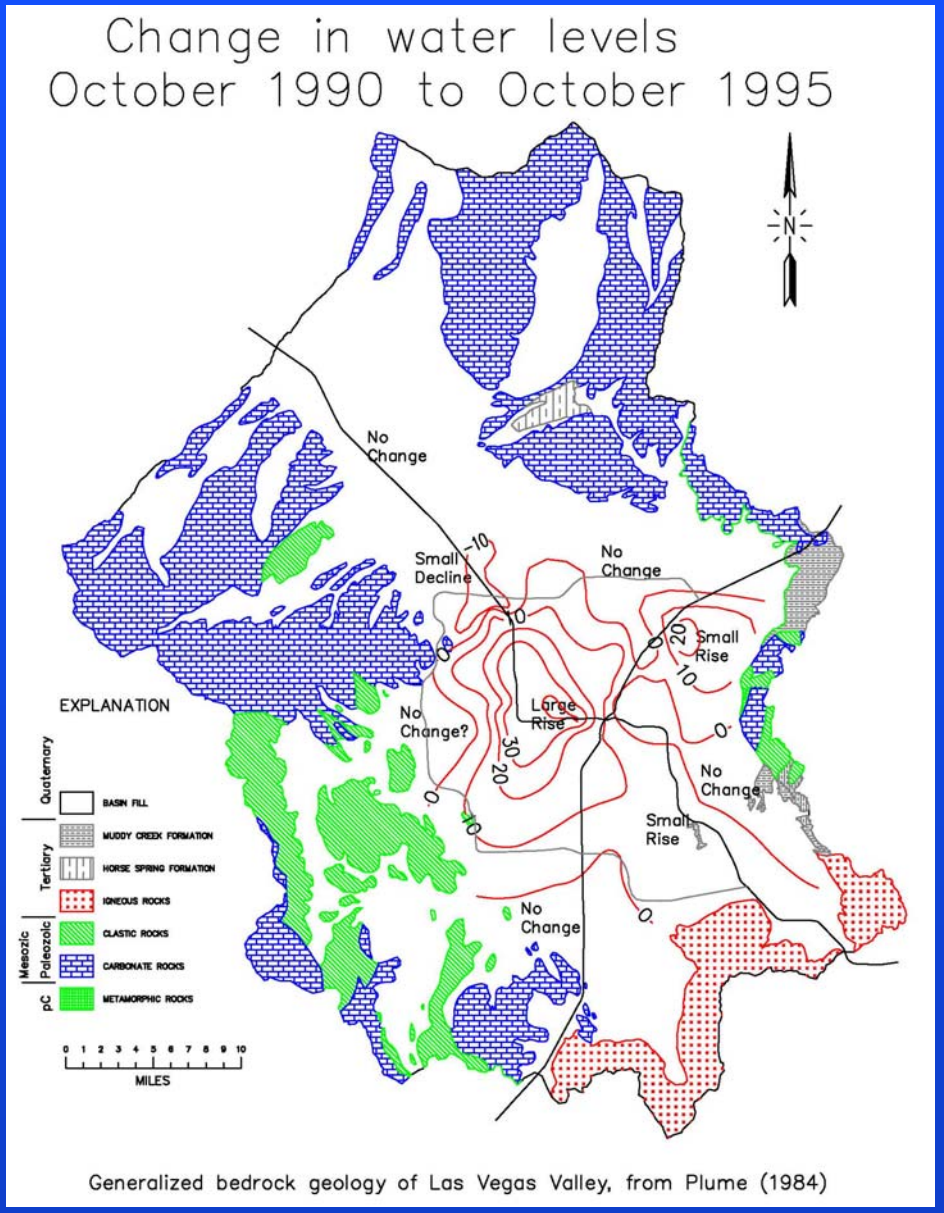
Change in Water Levels 1912-1990



Donovan (1997)

Contour Interval=10 ft
Blue=rise
Red=decline

1990 - 1995



Generalized bedrock geology of Las Vegas Valley, from Plume (1984)

1990 - 2000

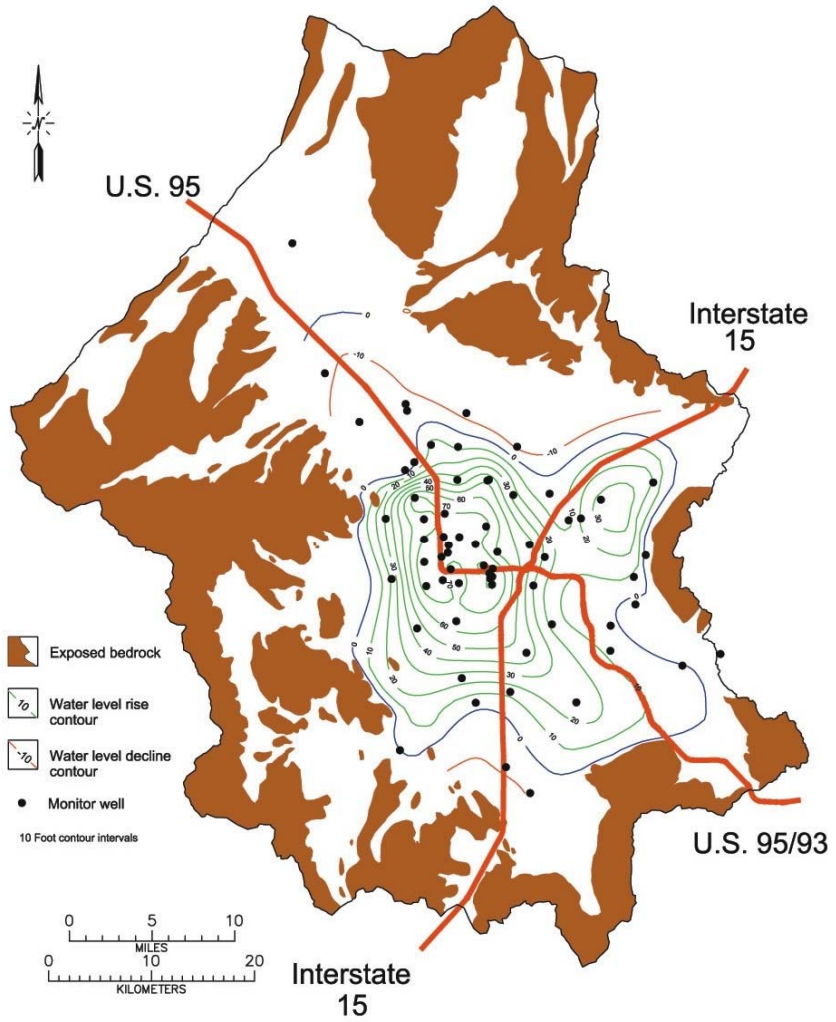
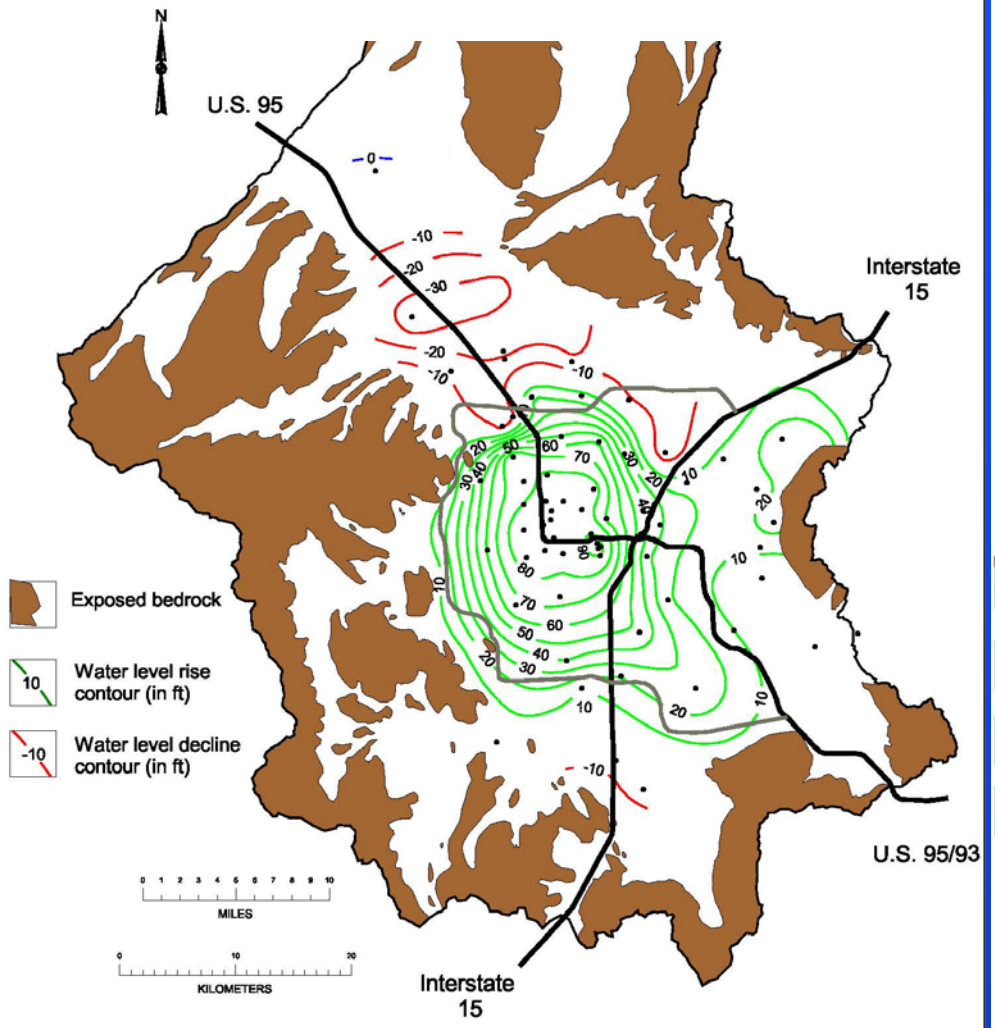


Figure 4. -- Water level change Fall 1990 to Fall 2000, in feet (water level decline, negative: water level rise, positive).

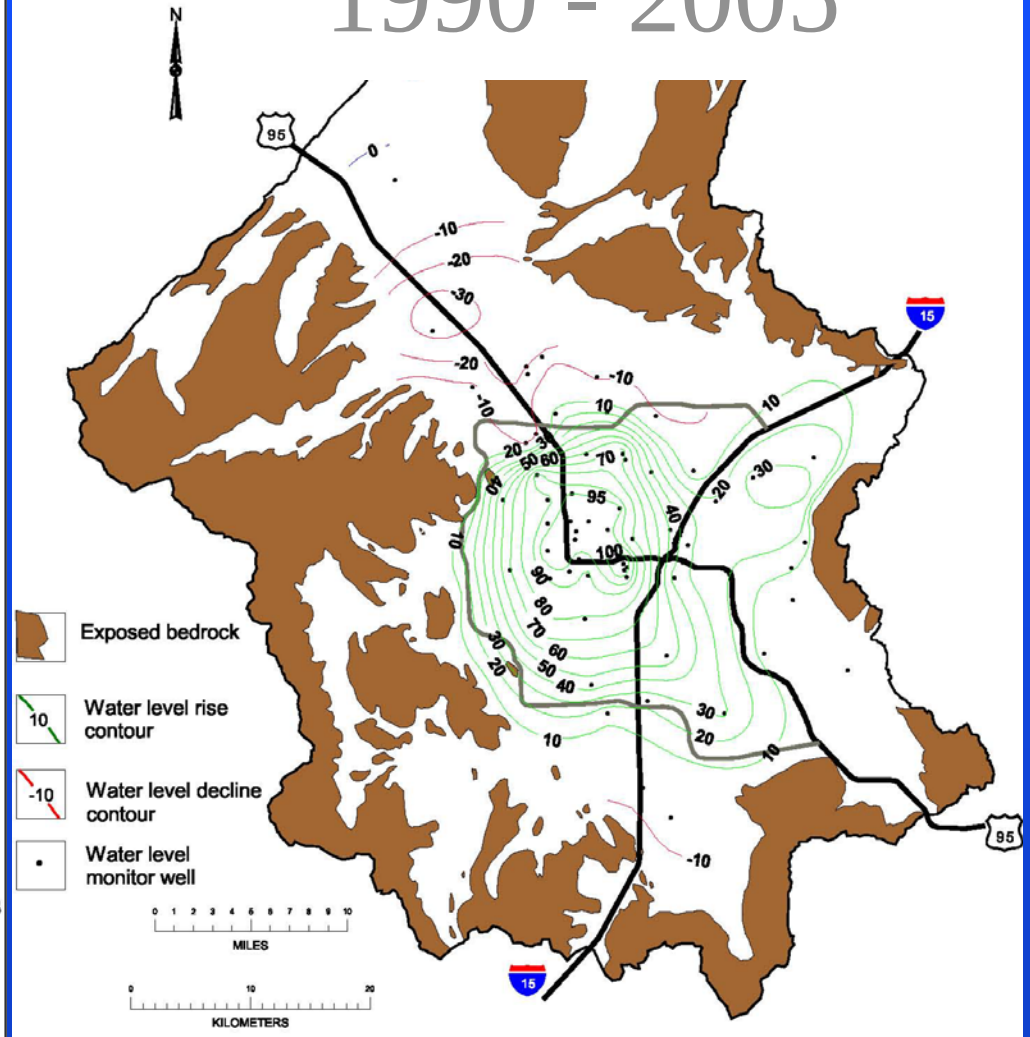
1990 - 2004



(water level decline, negative: water level rise, positive)

Figure 3. -- Change in potentiometric surface of the principal aquifer, Fall 1990 to Fall 2004

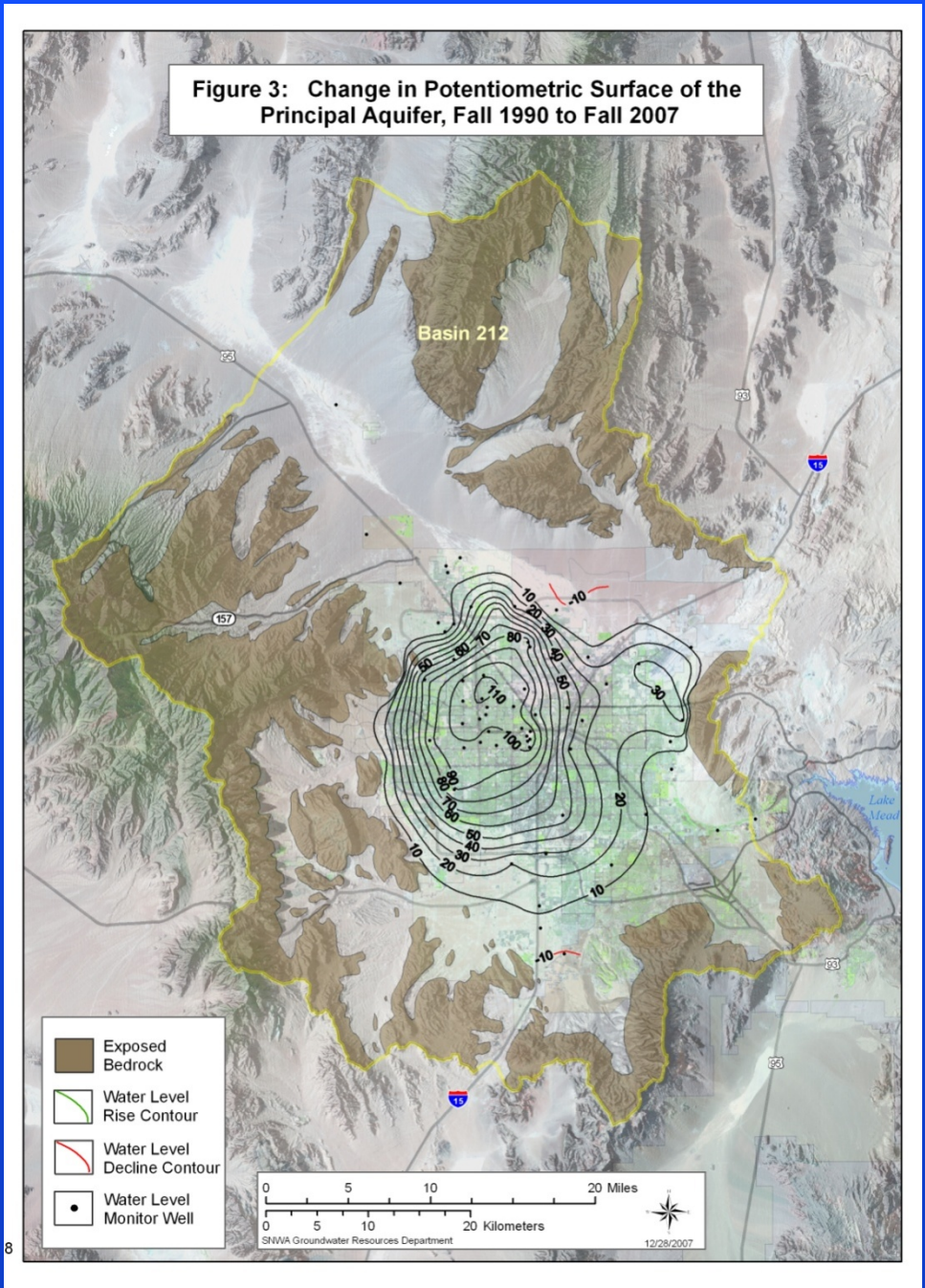
1990 - 2005



(water level decline, negative: water level rise, positive)

Figure 3: Change in potentiometric surface of the principal aquifer, Fall 1990 to Fall 2005

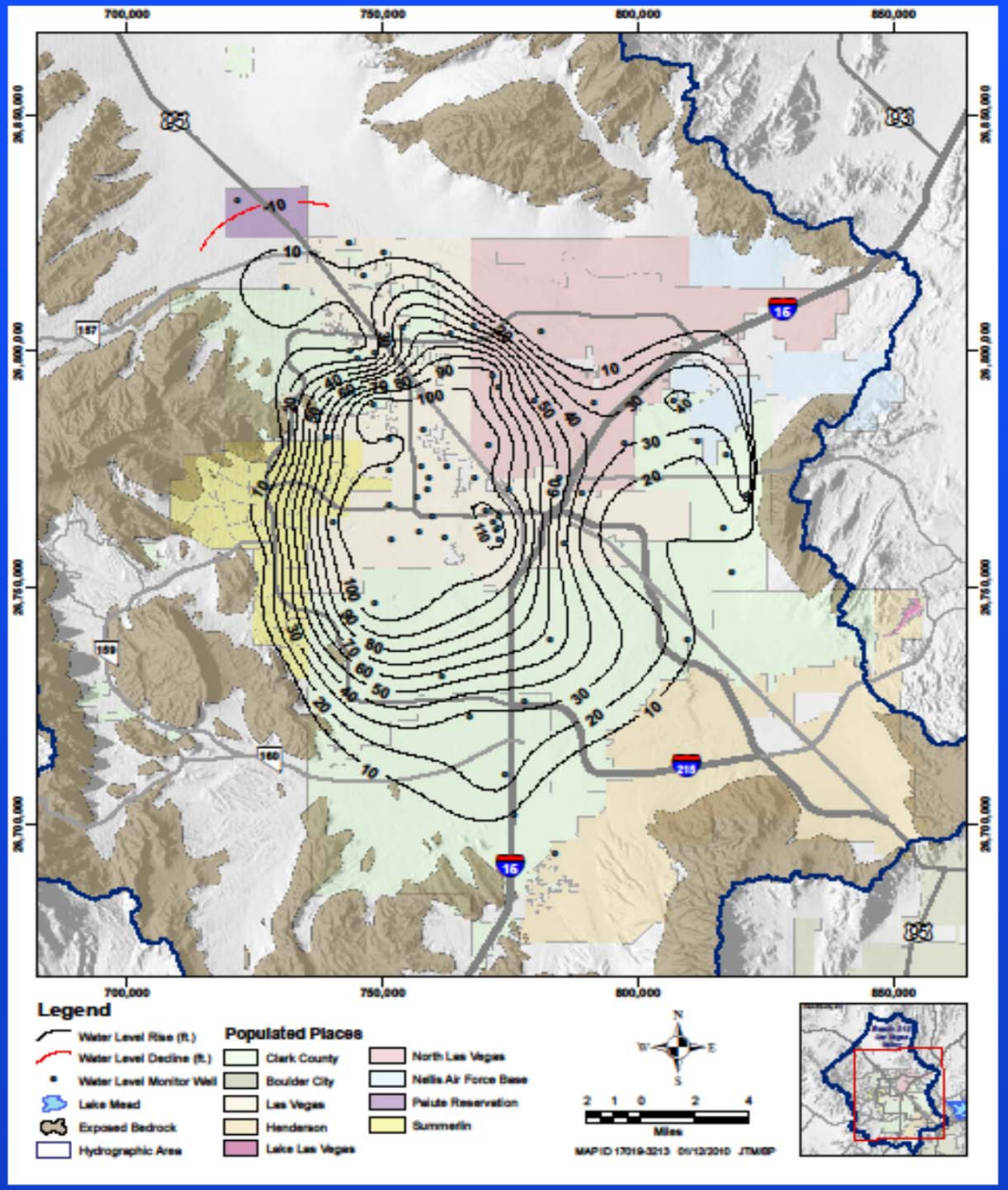
1990 - 2007



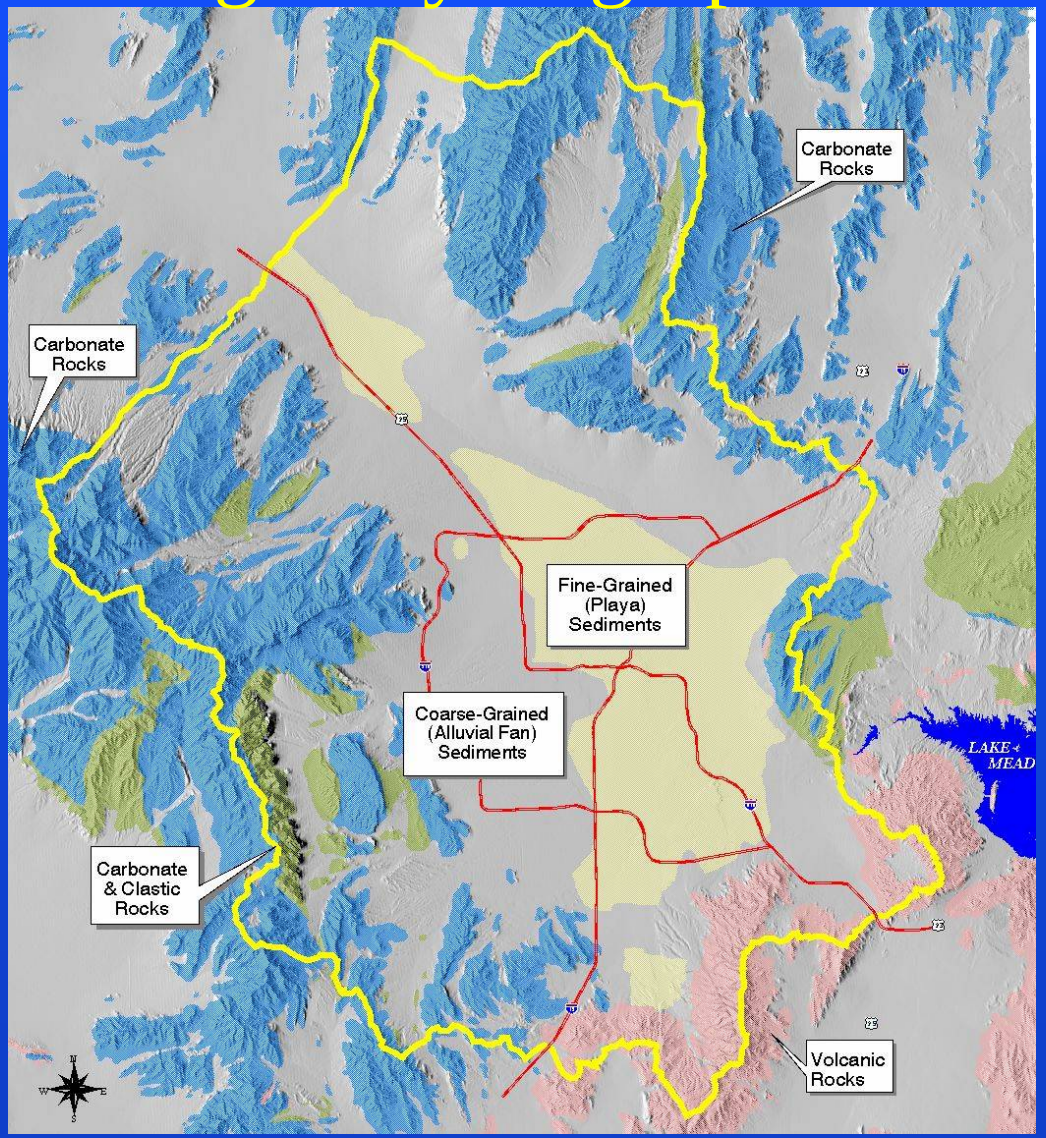
Contour Interval=10 ft
Green=rise
Red=decline

Change in Potentiometric Surface of the Las Vegas Valley Aquifer Fall 1990 – Fall 2009

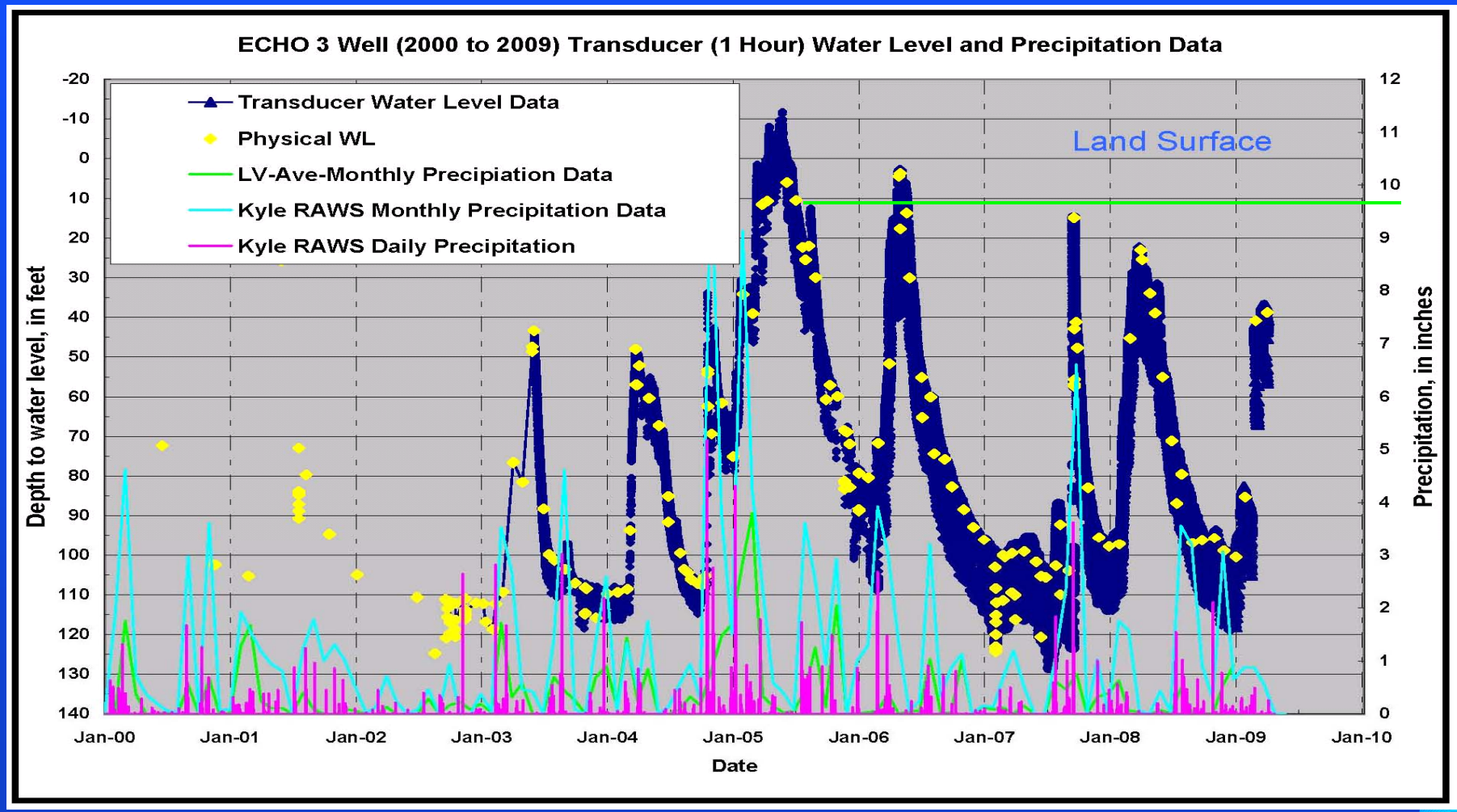
Contour Interval=10 ft.



Generalized Surface Geologic Map of the Las Vegas Hydrographic Basin



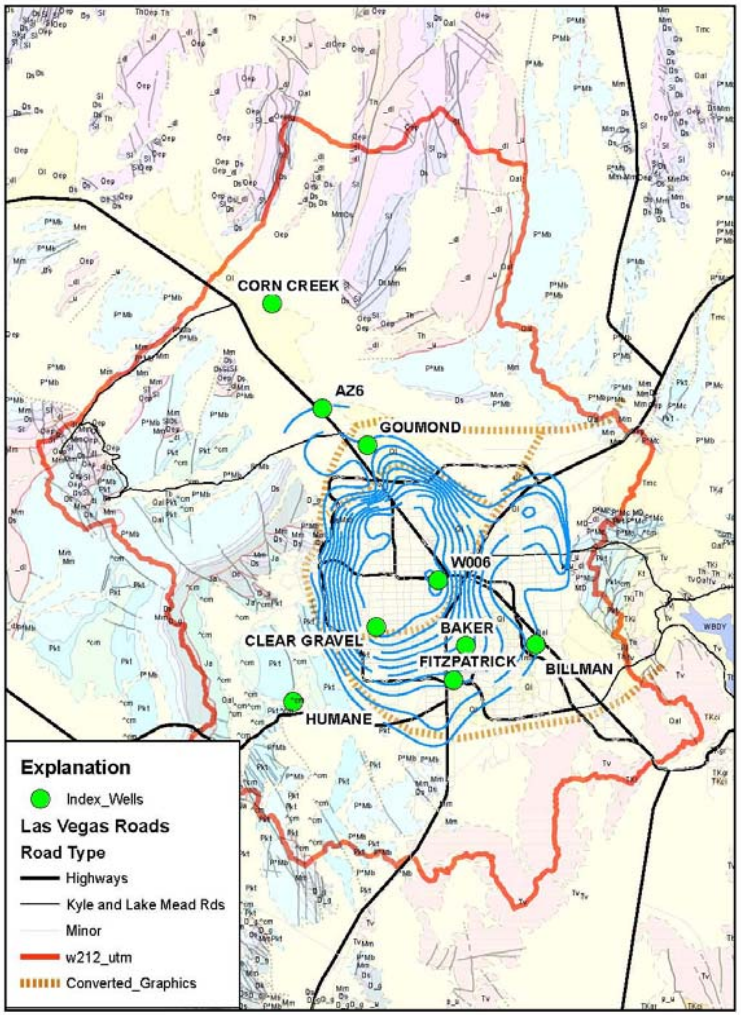
Kyle Hydrograph

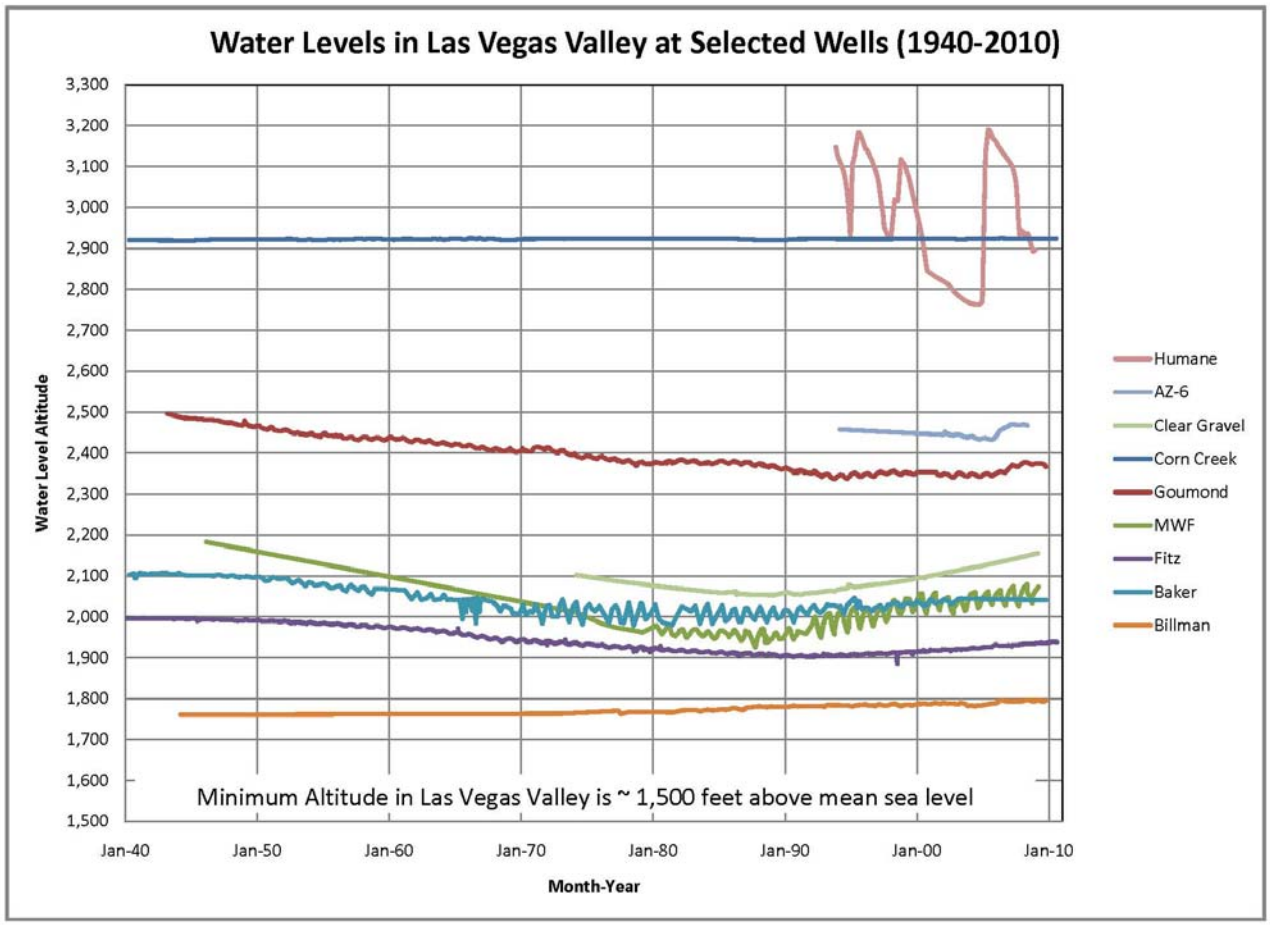


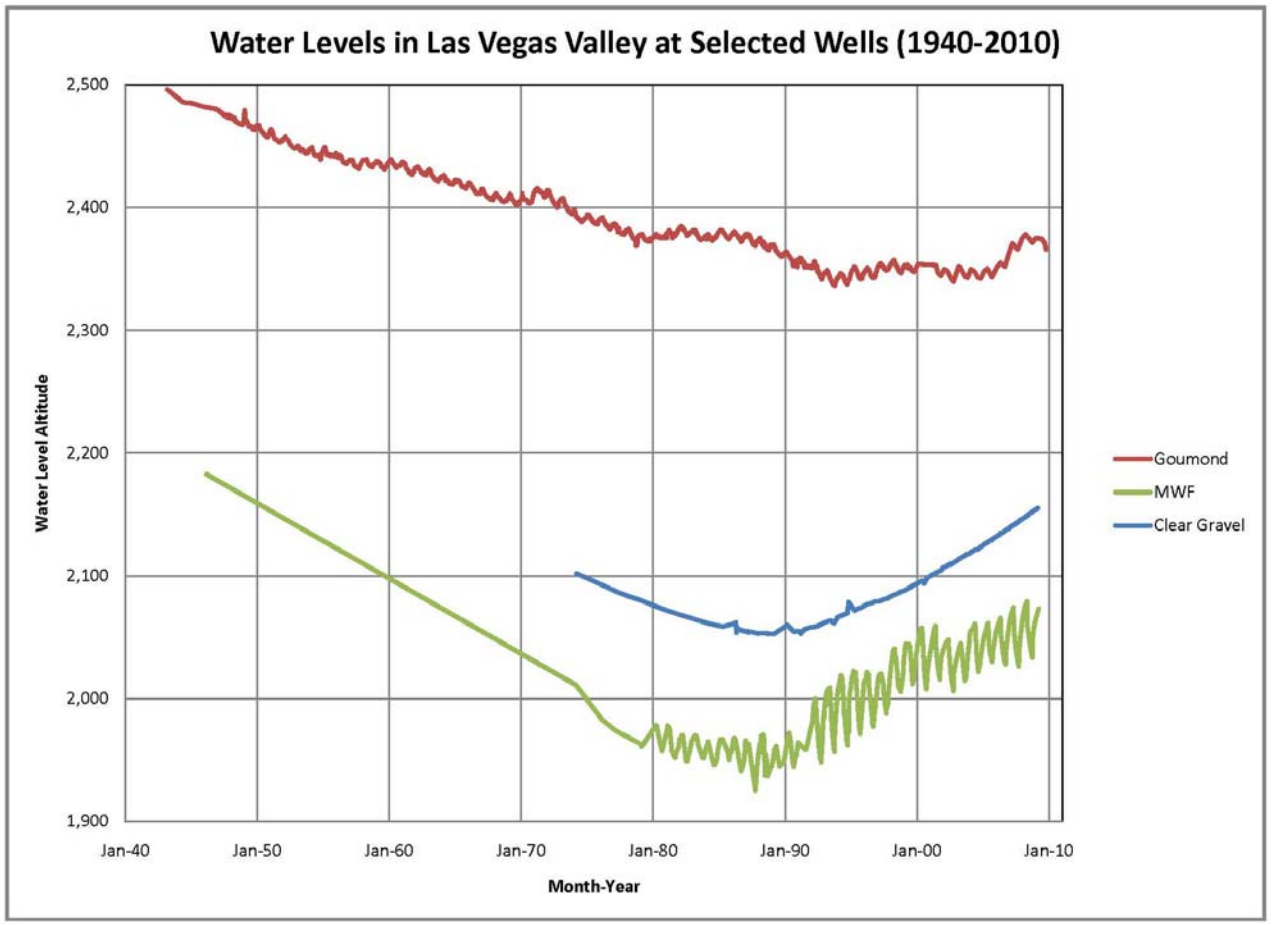
Location of Index Wells

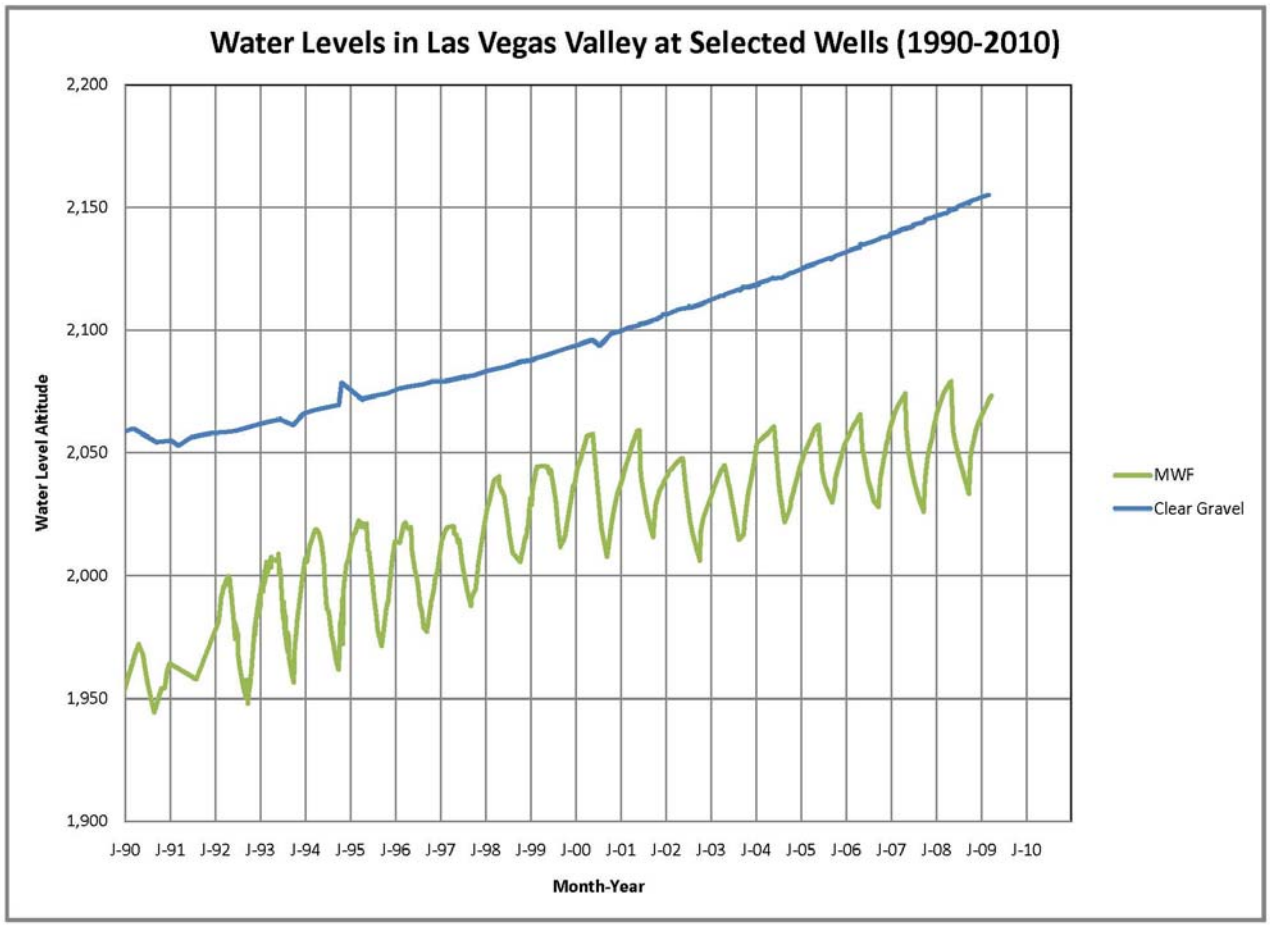
Green Dots

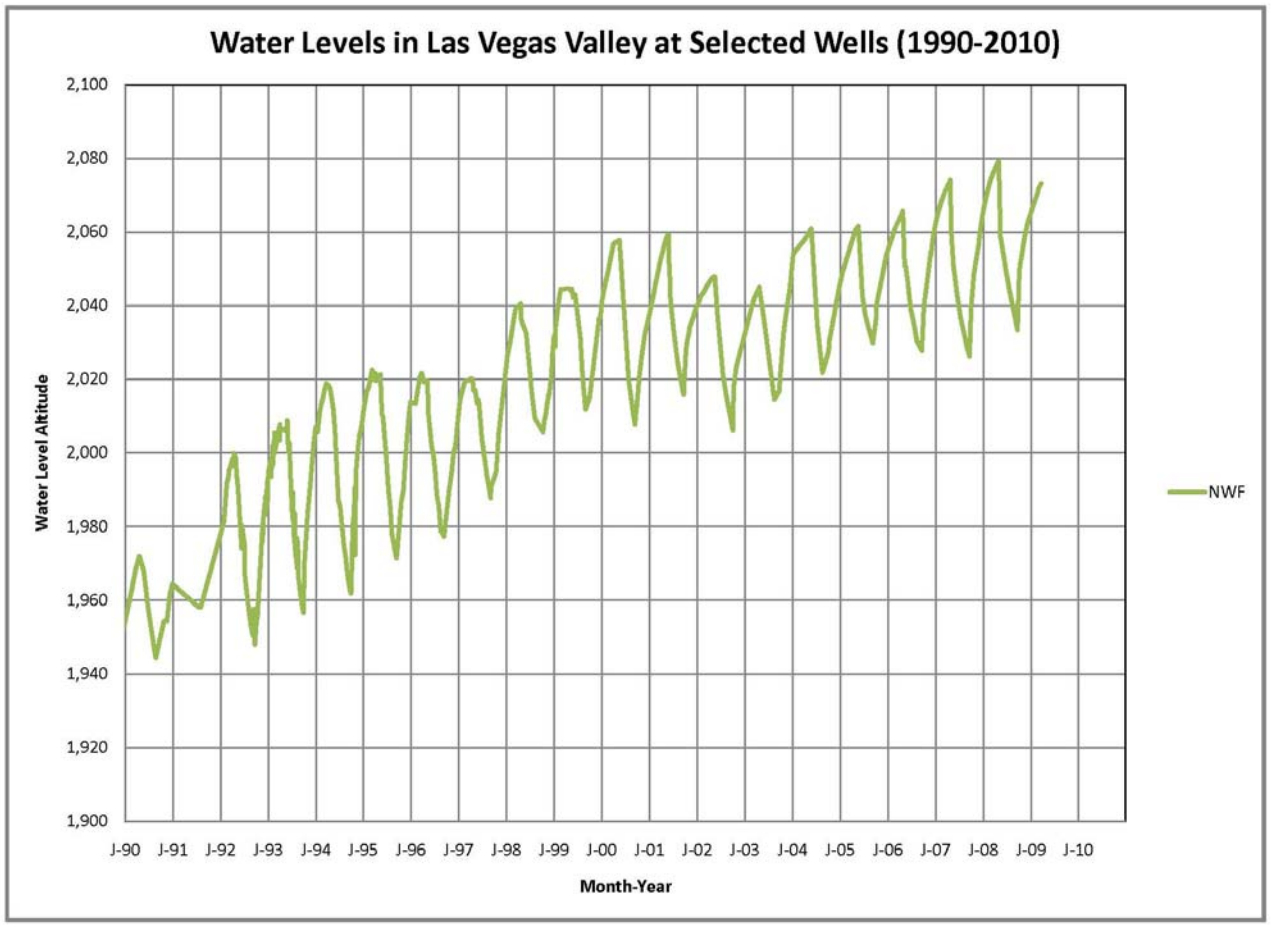
10 ft Contour Interval



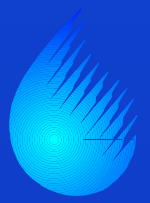

Water Levels in Las Vegas Valley at Selected Wells (1940-2010)
Water Level Altitude
3,300
3,200
3,100
3,000
2,900
2,800
2,700
2,600
2,500
2,400
2,300
2,200
2,100
2,000
1,900
1,800
1,700
1,600
1,500
Minimum Altitude in Las Vegas Valley is ~ 1,500 feet above mean sea level
Jan-40
Jan-50
Jan-60
Jan-70
Jan-80
Jan-90
Jan-00
Jan-10
Month-Year
Humane
AZ-6
Clear Gravel
Corn Creek
Goumond
MWF
Fitz
Baker
Billman


Water Levels in Las Vegas Valley at Selected Wells (1940-2010)
Water Level Altitude
2,500
2,400
2,300
2,200
2,100
2,000
1,900
Jan-40
Jan-50
Jan-60
Jan-70
Jan-80
Jan-90
Jan-00
Jan-10
Month-Year
Goumond
MWF
Clear Gravel


Water Levels in Las Vegas Valley at Selected Wells (1990-2010)
Water Level Altitude
2,200
2,150
2,100
2,050
2,000
1,950
1,900
J-90
J-91
J-92
J-93
J-94
J-95
J-96
J-97
J-98
J-99
J-00
J-01
J-02
J-03
J-04
J-05
J-06
J-07
J-08
J-09
J-10
Month-Year
MWF
Clear Gravel


Water Levels in Las Vegas Valley at Selected Wells (1990-2010)
Water Level Altitude
2,100
2,080
2,060
2,040
2,020
2,000
1,980
1,960
1,940
1,920
1,900
J-90
J-91
J-92
J-93
J-94
J-95
J-96
J-97
J-98
J-99
J-00
J-01
J-02
J-03
J-04
J-05
J-06
J-07
J-08
J-09
J-10
Month-Year
NWF

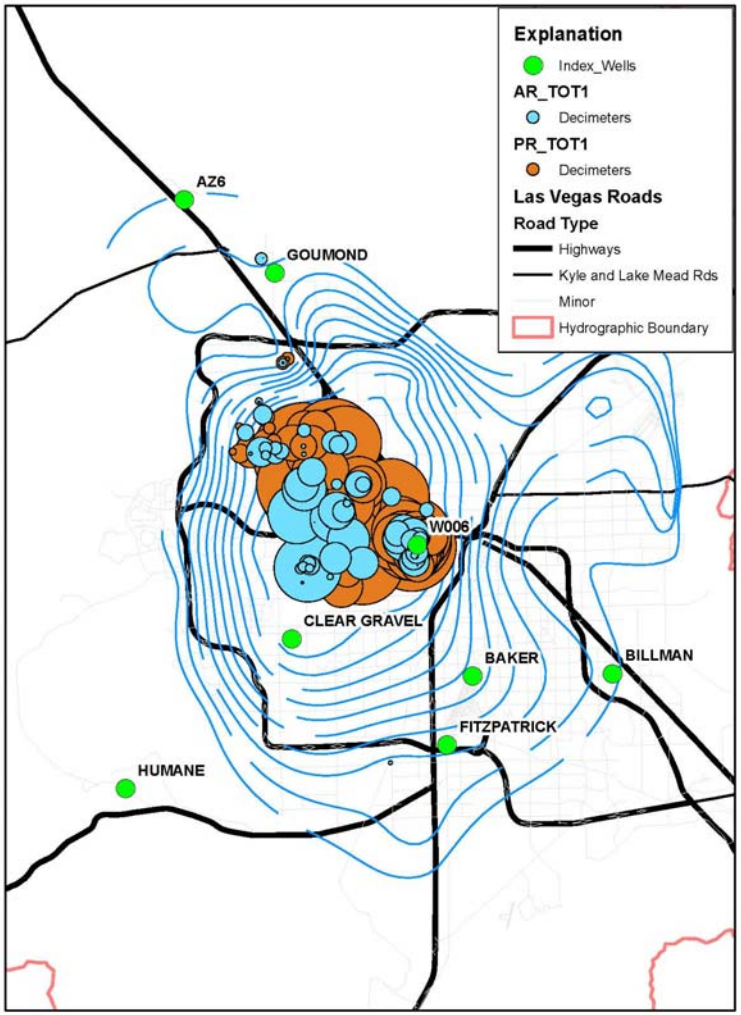
Operation Change Since 2000



Production and AR through Time (District)

Production (Brown)

AR (Lt Blue)



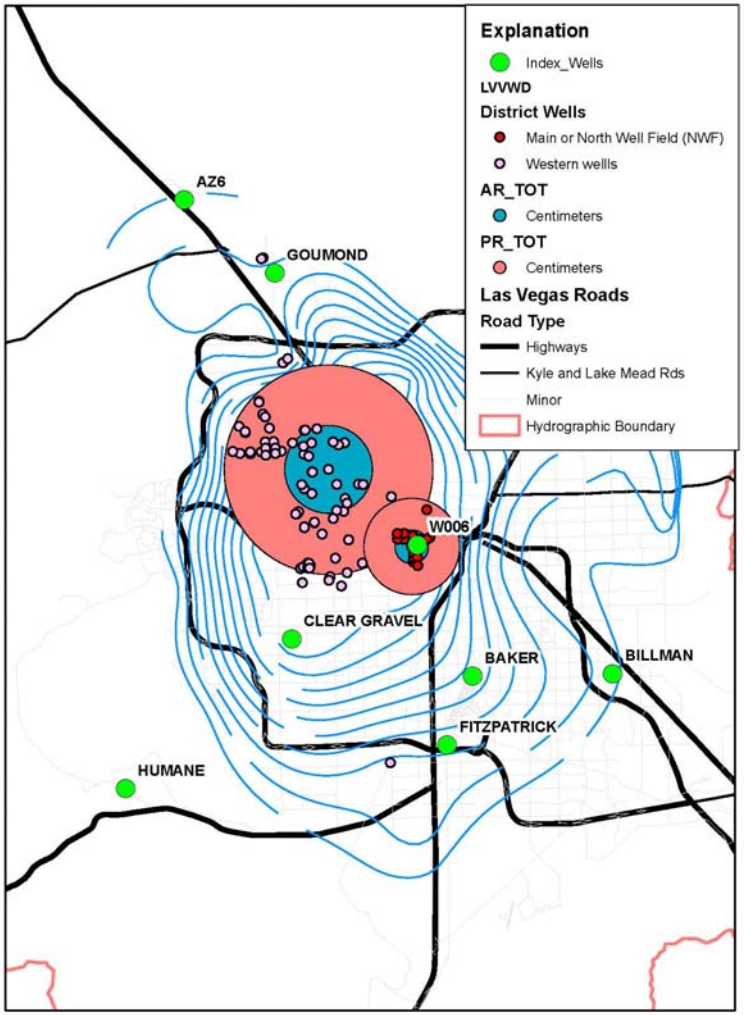
Production and AR through Time (District)

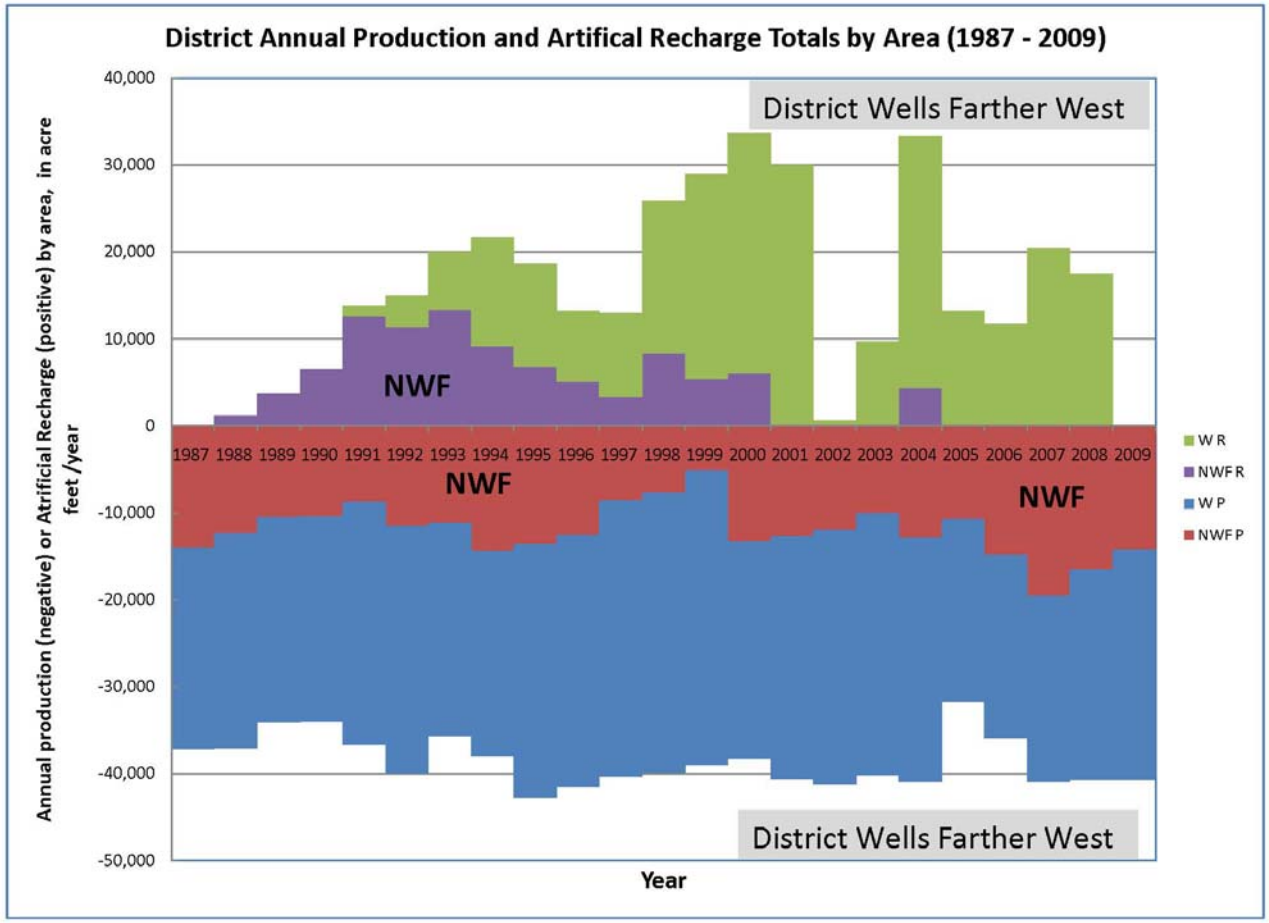
Main or North WF

Other District Wells

Production (Pink)

AR (Blue)



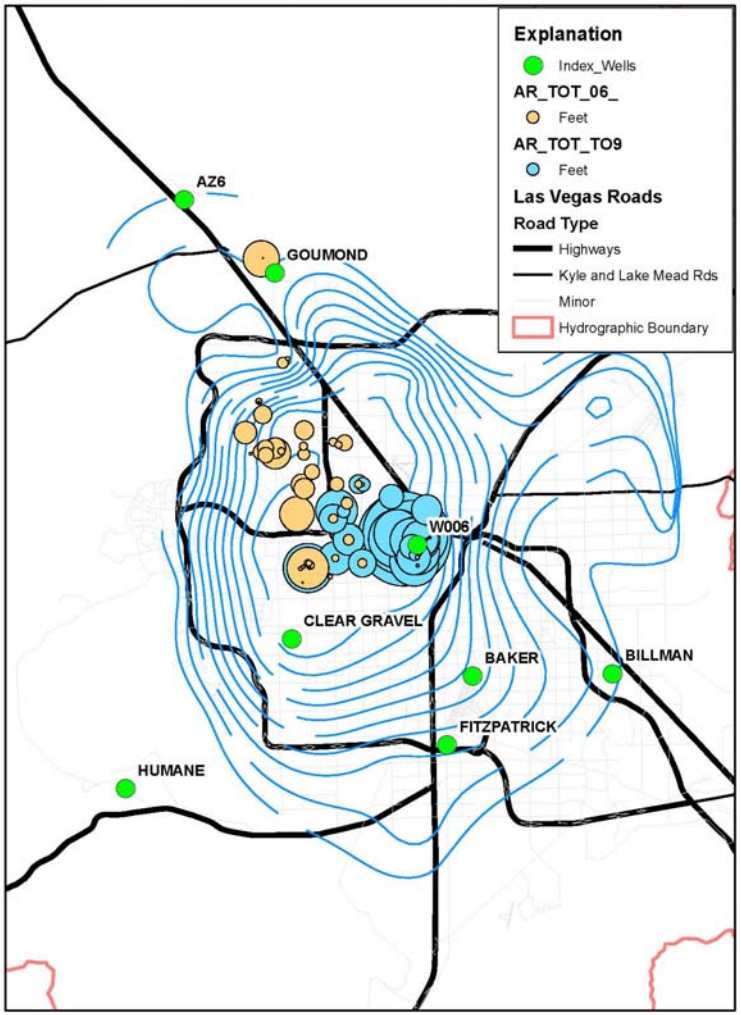

District Annual Production and Artifical Recharge Totals by Area (1987 - 2009)
Annual production (negative) or Atrificial Recharge (positive) by area, in acre feet /year
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
-50,000
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Year
District Wells Farther West
NWF
NWF
NWF
District Wells Farther West
W R
NWF R
W P
NWF P

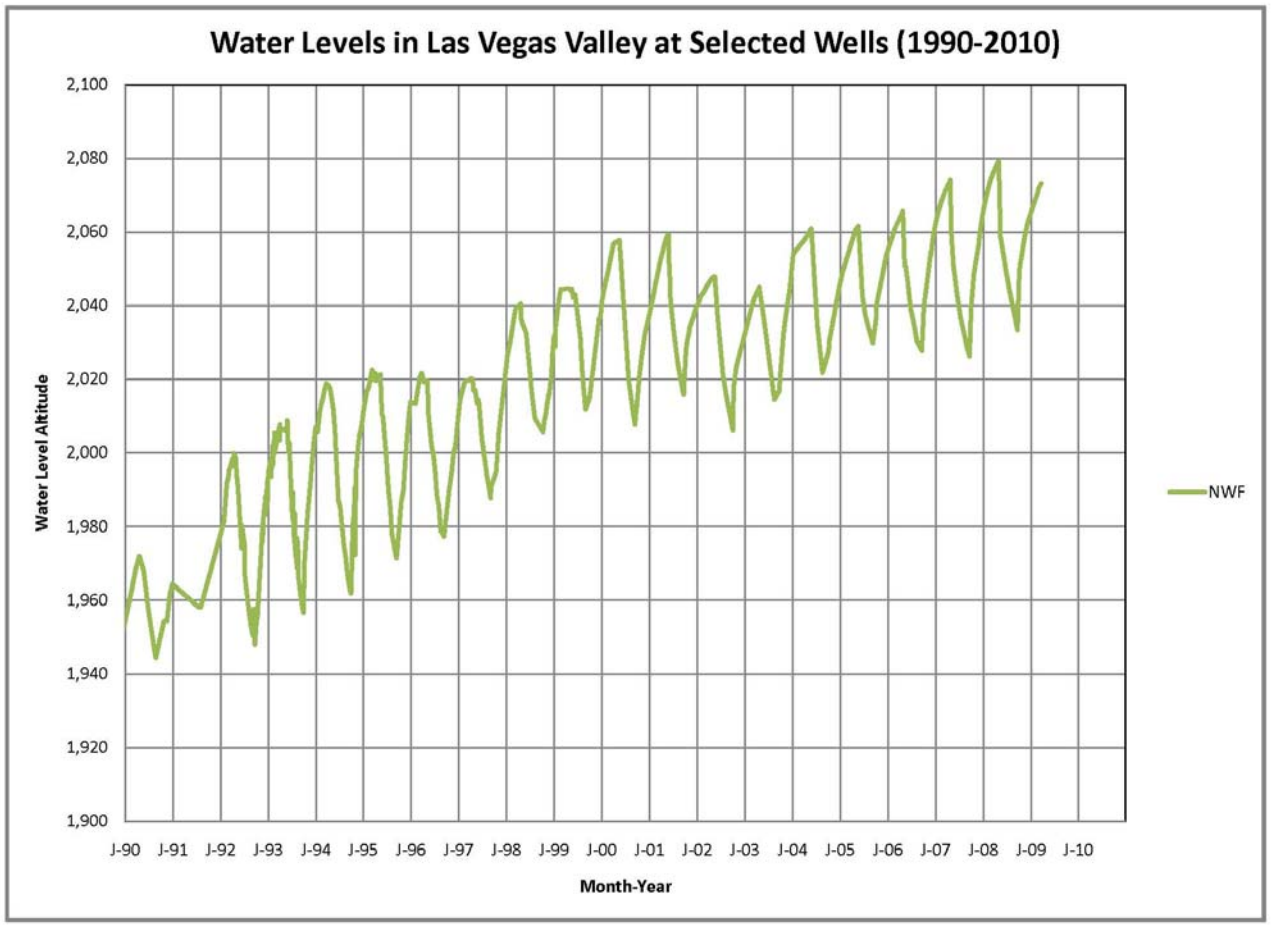
Location / Volume of AR though Time

AR

1987-1995 (Blue)

2005-2009 (Tan)

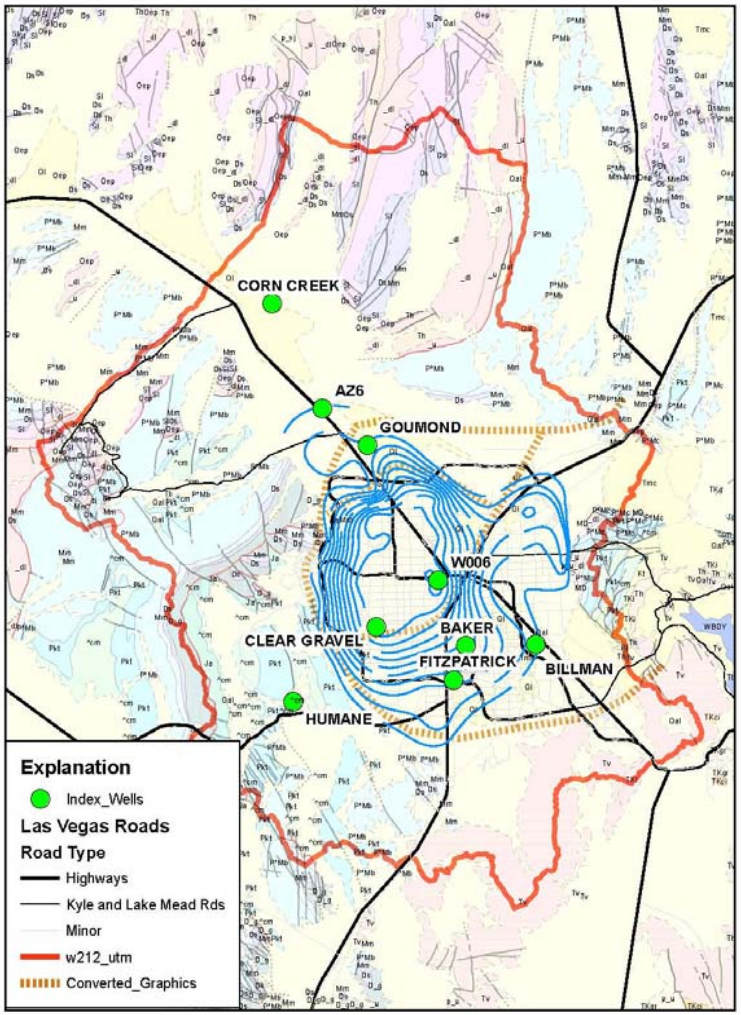


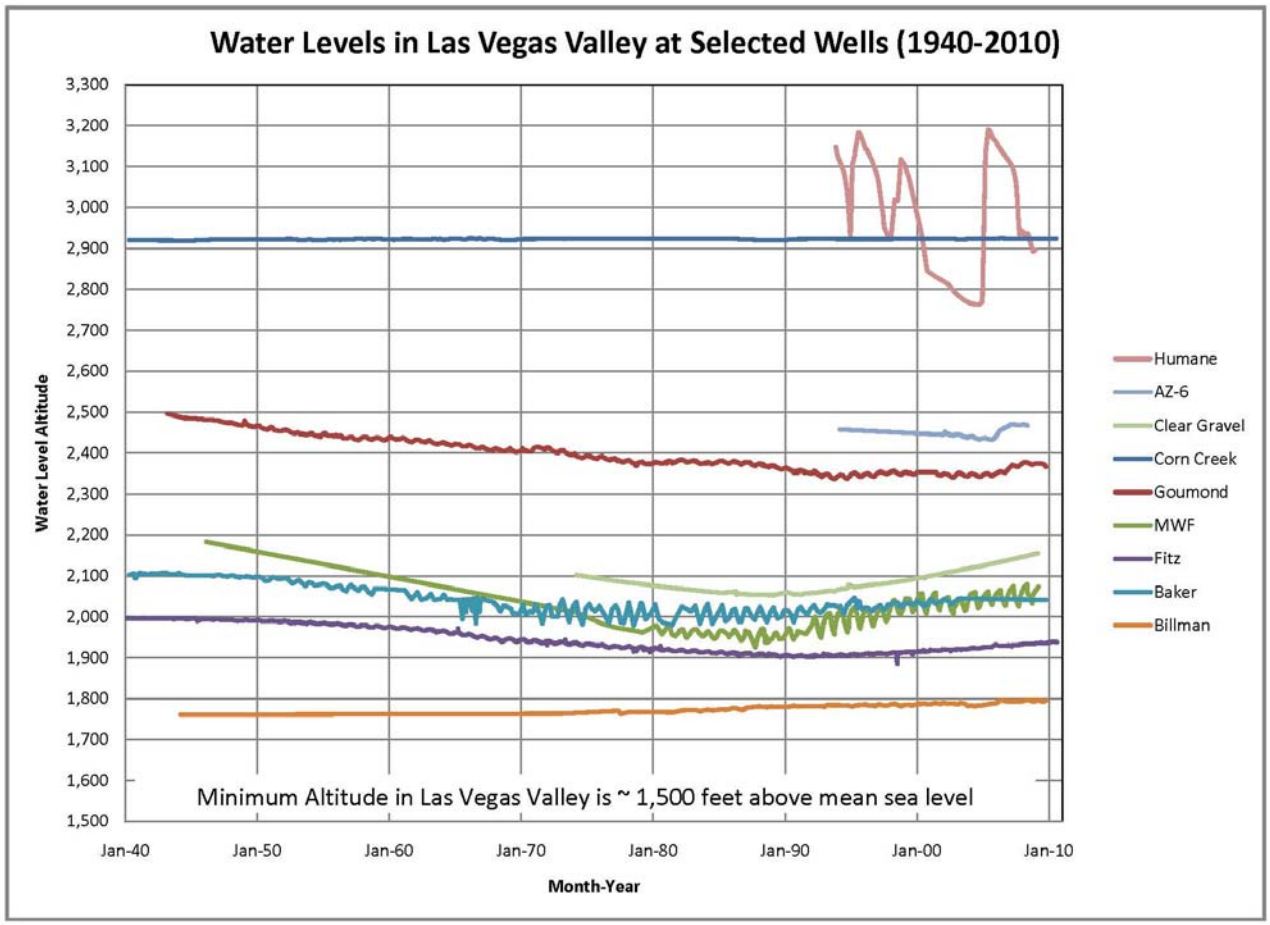

Water Levels in Las Vegas Valley at Selected Wells (1990-2010)
Water Level Altitude
2,100
2,080
2,060
2,040
2,020
2,000
1,980
1,960
1,940
1,920
1,900
J-90
J-91
J-92
J-93
J-94
J-95
J-96
J-97
J-98
J-99
J-00
J-01
J-02
J-03
J-04
J-05
J-06
J-07
J-08
J-09
J-10
Month-Year
NWF

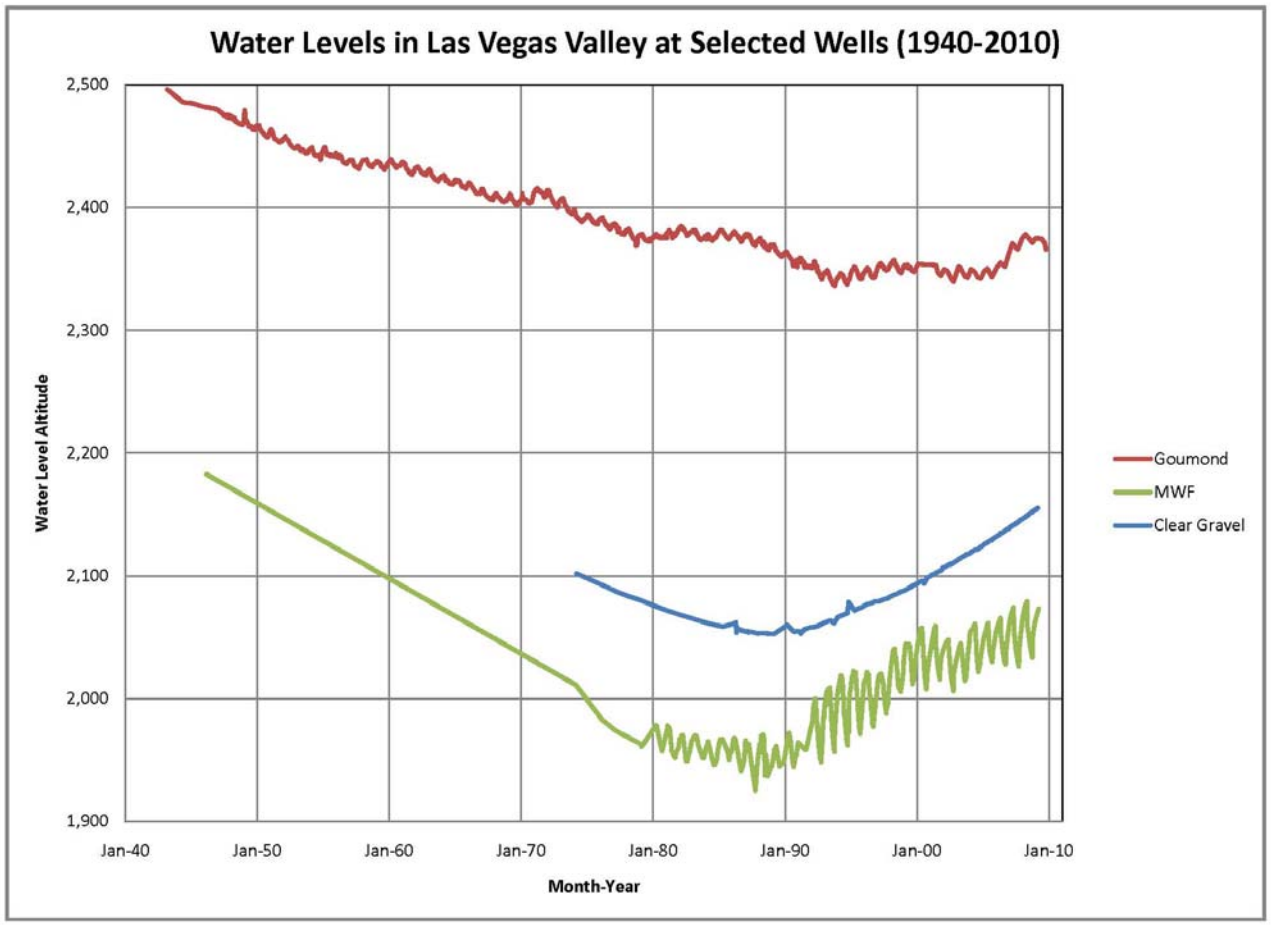
Location of Index Wells

Green Dots

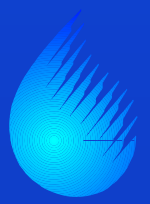
10 ft Contour Interval

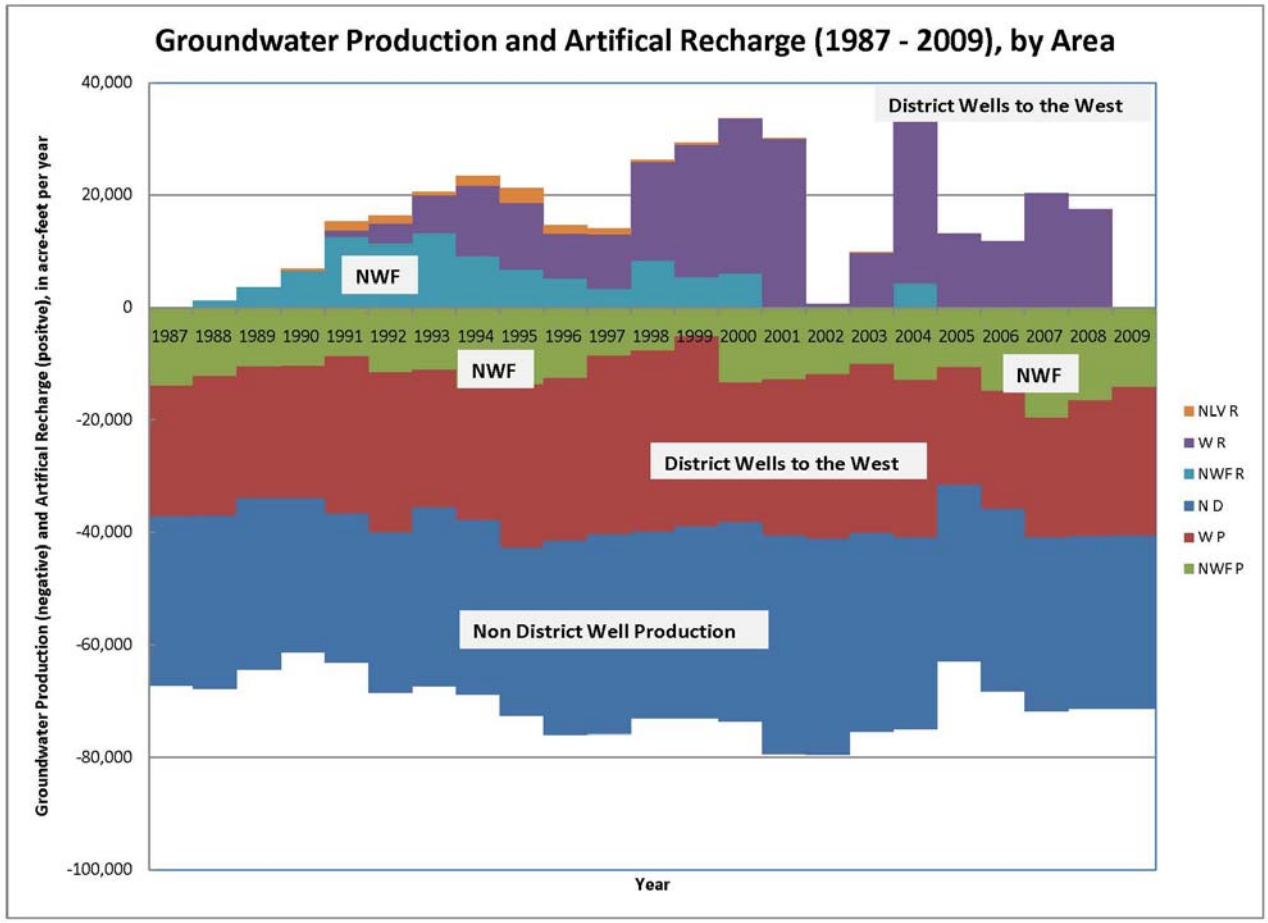



Water Levels in Las Vegas Valley at Selected Wells (1940-2010)
Water Level Altitude
3,300
3,200
3,100
3,000
2,900
2,800
2,700
2,600
2,500
2,400
2,300
2,200
2,100
2,000
1,900
1,800
1,700
1,600
1,500
Minimum Altitude in Las Vegas Valley is ~ 1,500 feet above mean sea level
Jan-40
Jan-50
Jan-60
Jan-70
Jan-80
Jan-90
Jan-00
Jan-10
Month-Year
Humane
AZ-6
Clear Gravel
Corn Creek
Goumond
MWF
Fitz
Baker
Billman


Water Levels in Las Vegas Valley at Selected Wells (1940-2010)
Water Level Altitude
2,500
2,400
2,300
2,200
2,100
2,000
1,900
Jan-40
Jan-50
Jan-60
Jan-70
Jan-80
Jan-90
Jan-00
Jan-10
Month-Year
Goumond
MWF
Clear Gravel

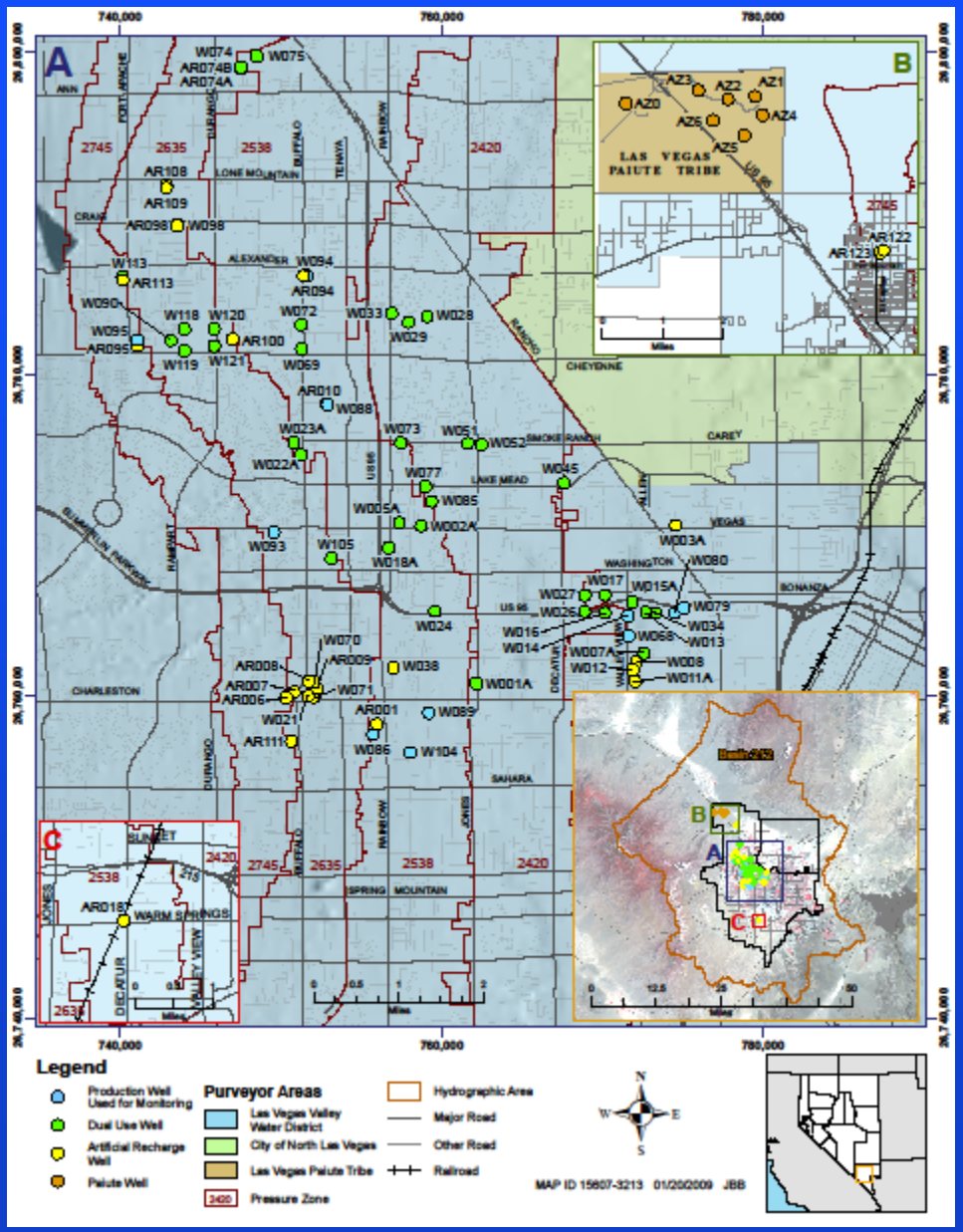
Non District Operations

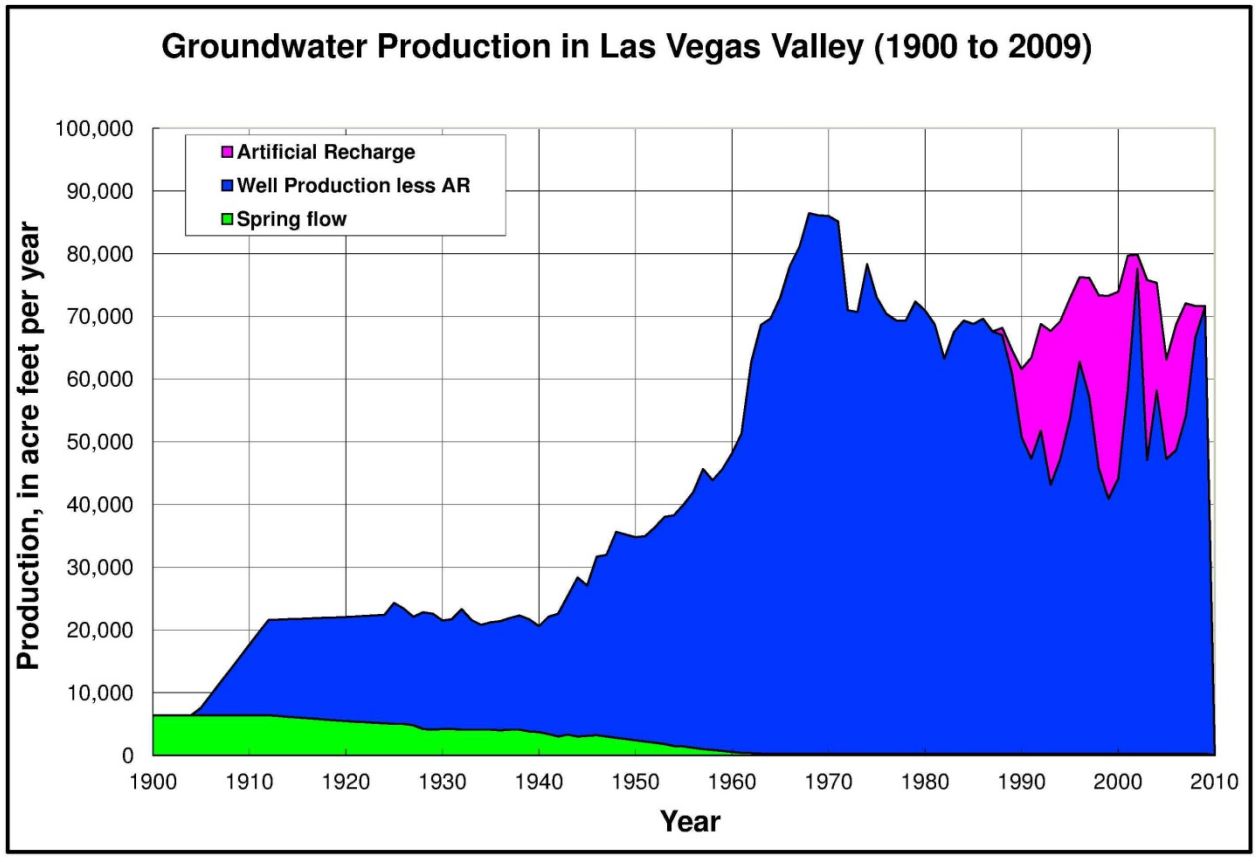



Groundwater Production and Artifical Recharge (1987 - 2009), by Area
Groundwater Production (negative) and Artifical Recharge (positive), in acre-feet per year
40,000
20,000
0
-20,000
-40,000
-60,000
-80,000
-100,000
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Year
District Wells to the West
NWF
NWF
NWF
District Wells to the West
Non District Well Production
NLV R
W R
NWF R
N D
W P
NWF P

Location of LVVWD wells used for artificial recharge and groundwater production

- Dedicated AR Wells
- Dual Use Wells
- Production Wells




Groundwater Production in Las Vegas Valley (1900 to 2009)
Artificial Recharge
Well Production less AR
Spring flow
Production, in acre feet per year
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

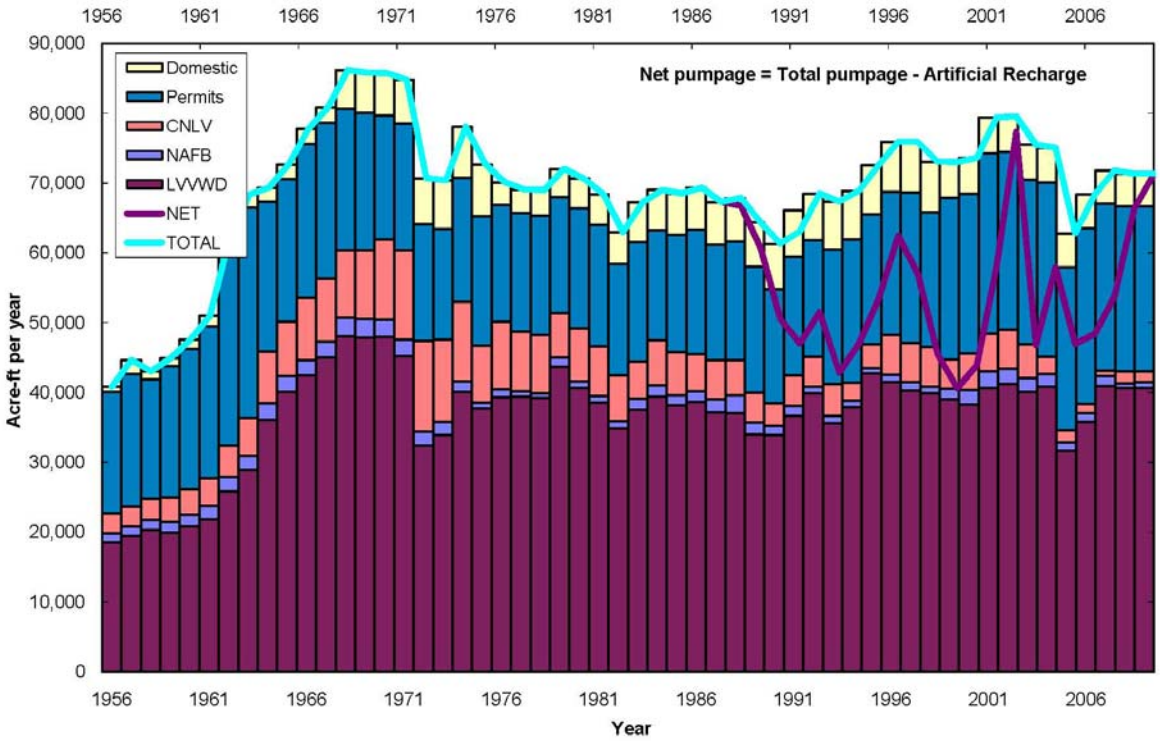
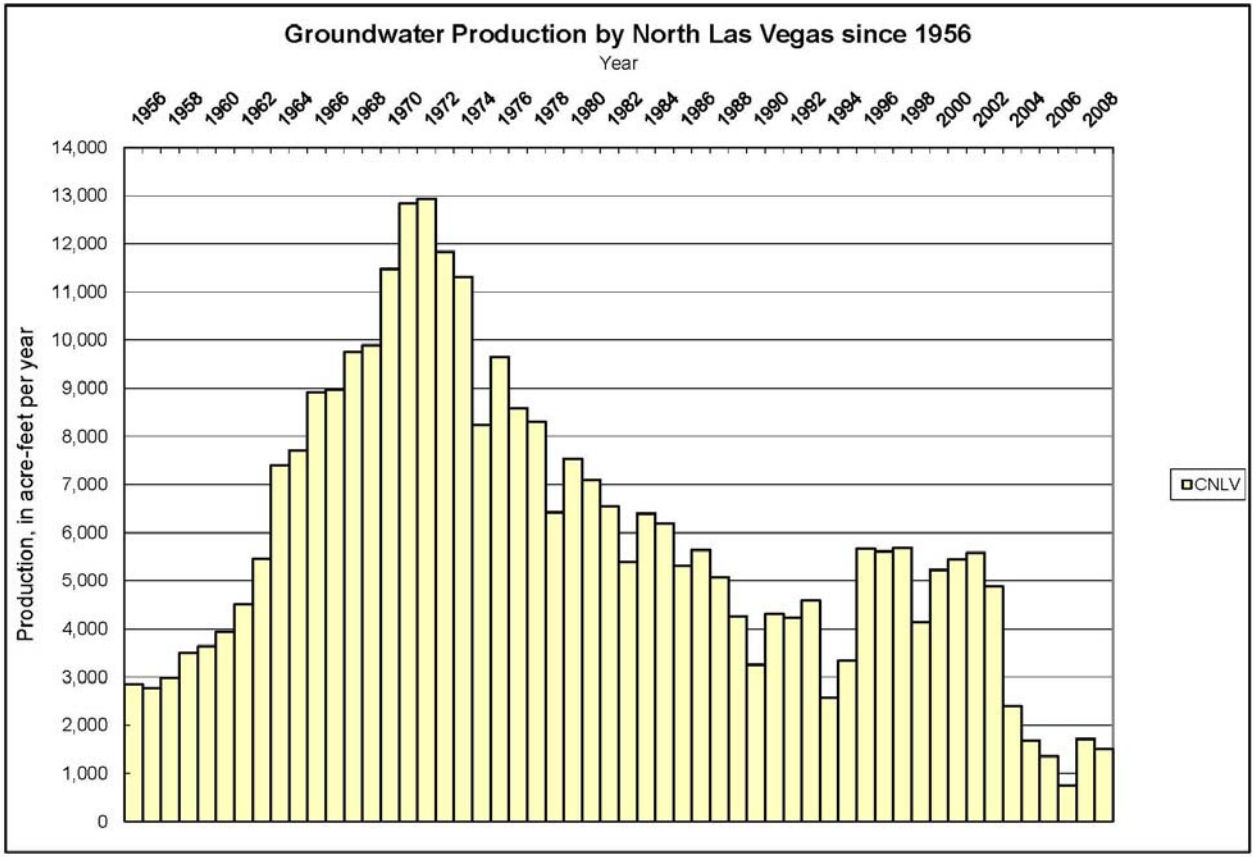
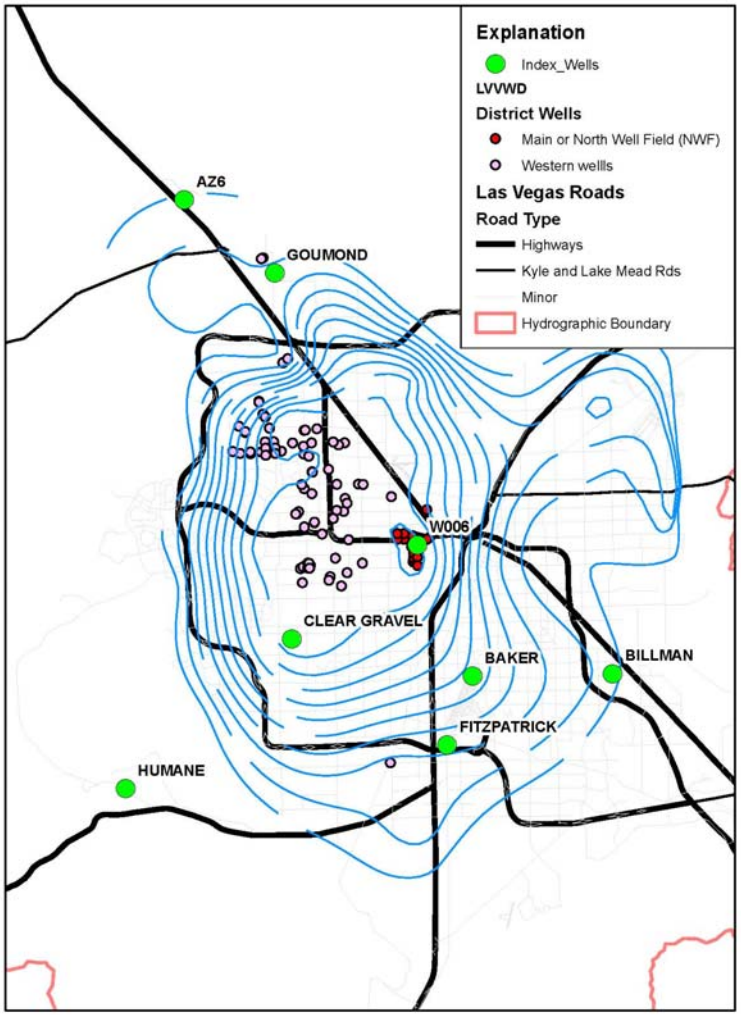


Figure 2. -- Total ground-water pumpage in Las Vegas Valley, by type of pumper, 1956 to 2009

CNLV


Groundwater Production by North Las Vegas since 1956
Year
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Production, in acre-feet per year
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
CNLV

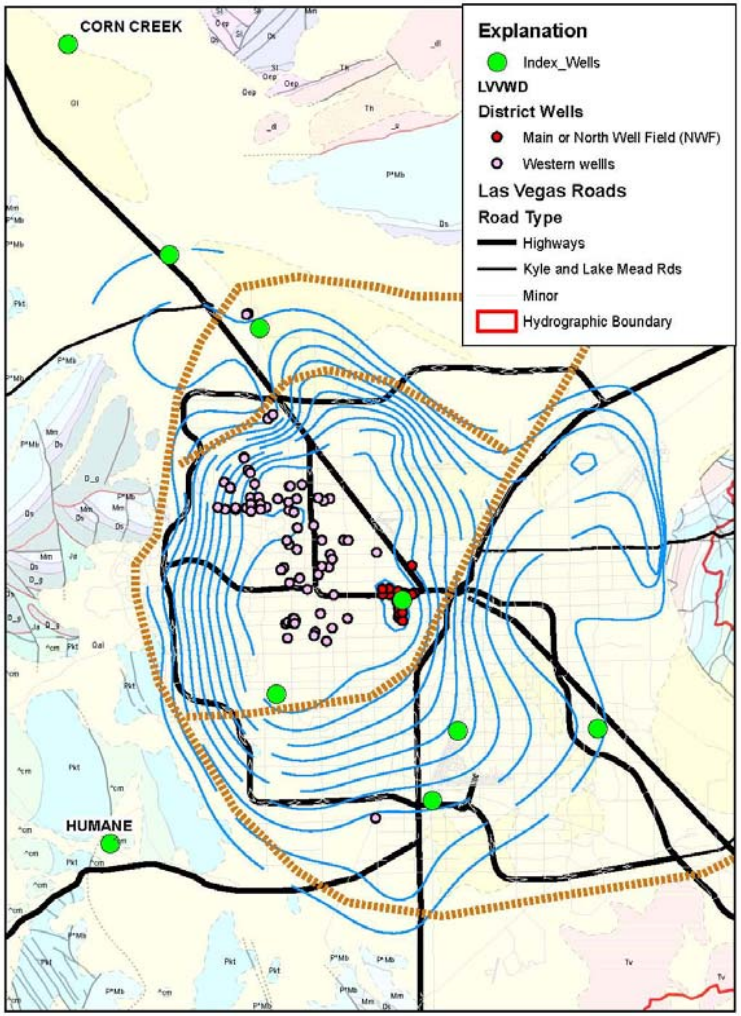
District wells and water level rise

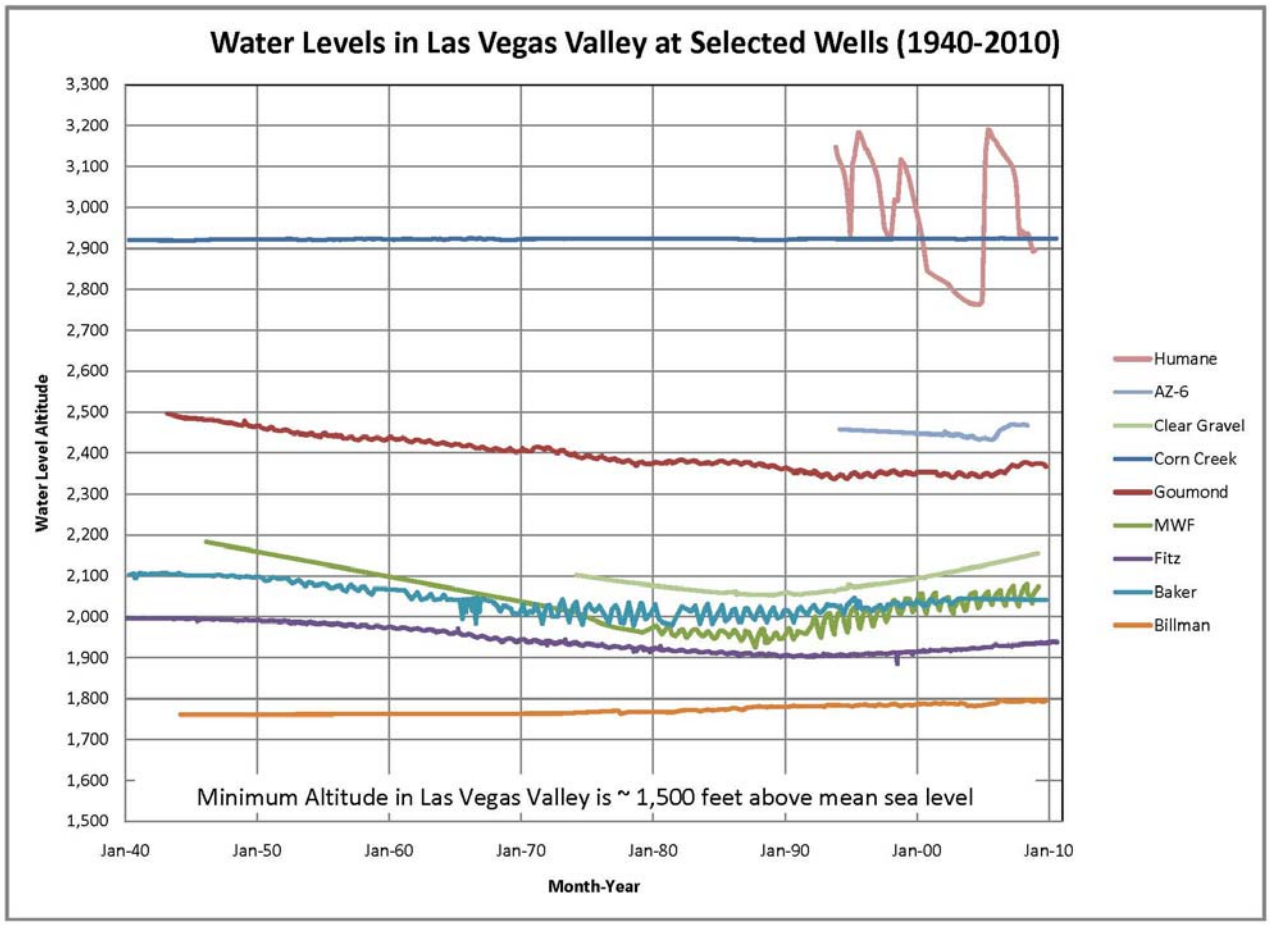


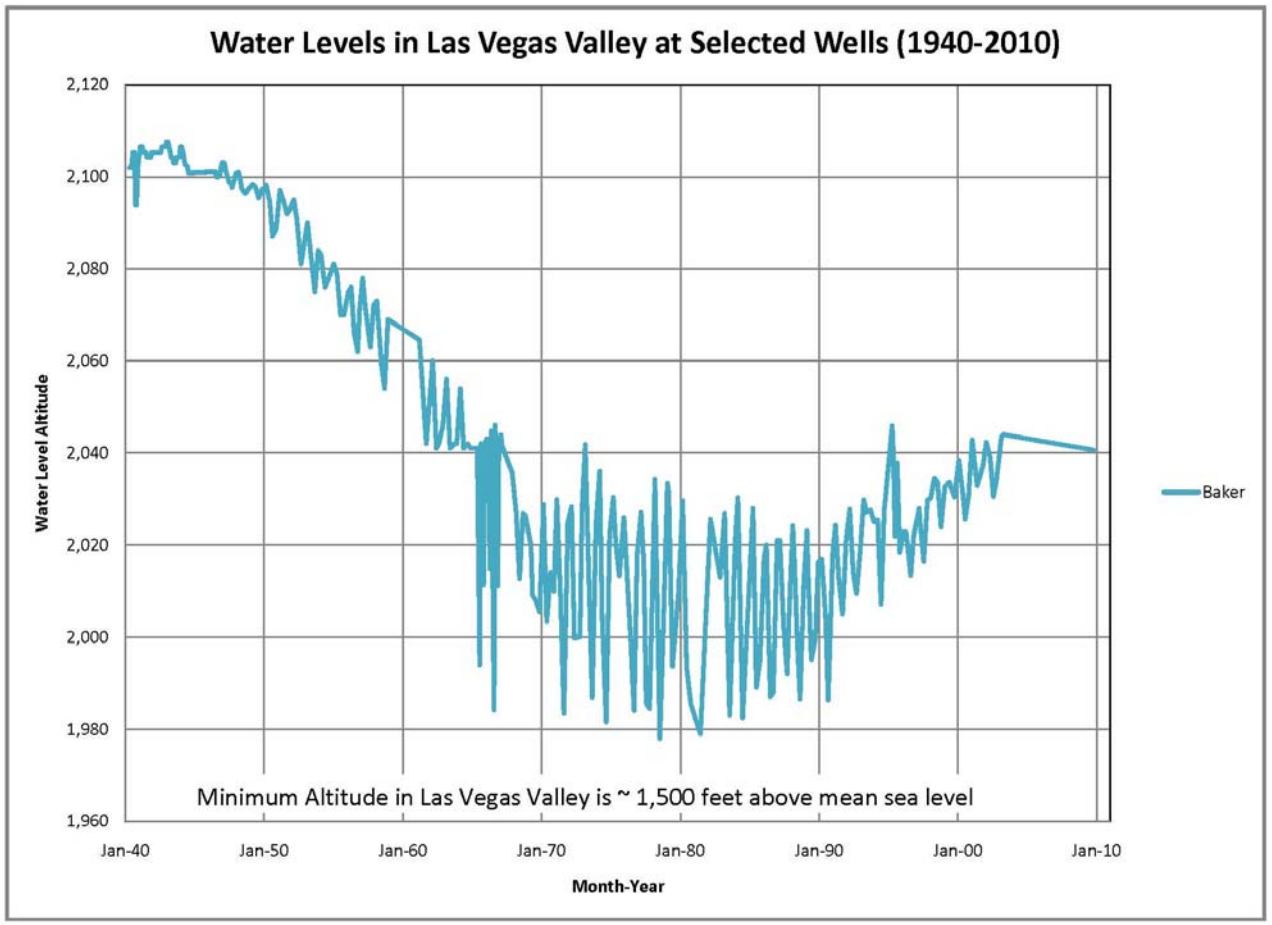
District wells and water level rise

Other Areas

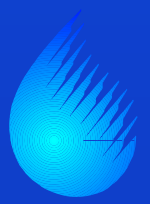
(preliminary boundaries)




Water Levels in Las Vegas Valley at Selected Wells (1940-2010)
Water Level Altitude
3,300
3,200
3,100
3,000
2,900
2,800
2,700
2,600
2,500
2,400
2,300
2,200
2,100
2,000
1,900
1,800
1,700
1,600
1,500
Minimum Altitude in Las Vegas Valley is ~ 1,500 feet above mean sea level
Jan-40
Jan-50
Jan-60
Jan-70
Jan-80
Jan-90
Jan-00
Jan-10
Month-Year
Humane
AZ-6
Clear Gravel
Corn Creek
Goumond
MWF
Fitz
Baker
Billman

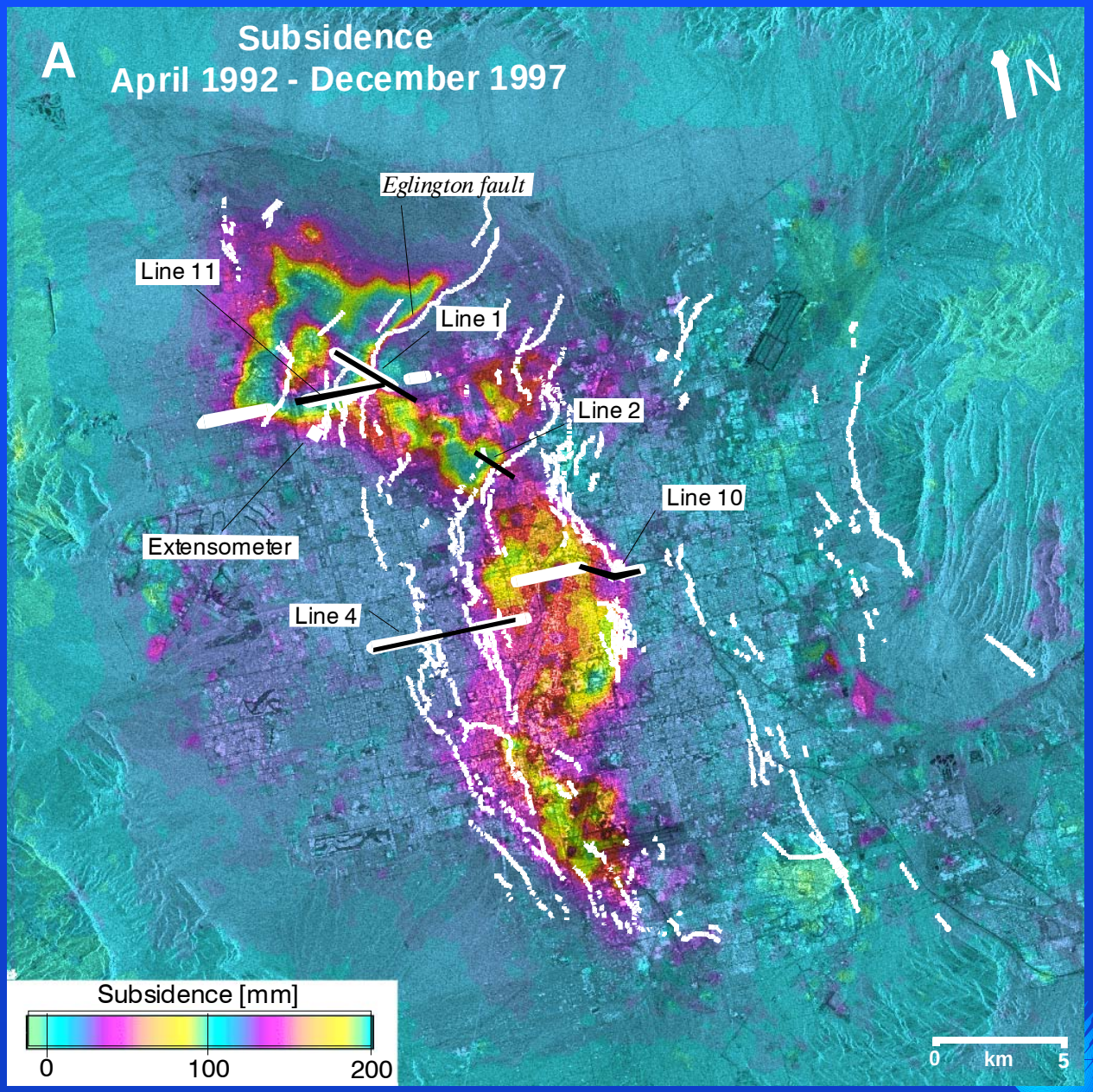

Water Levels in Las Vegas Valley at Selected Wells (1940-2010)
2,120
2,100
2,080
2,060
2,040
2,020
2,000
1,980
1,960
Water Level Altitude
Minimum Altitude in Las Vegas Valley is ~ 1,500 feet above mean sea level
Jan-40
Jan-50
Jan-60
Jan-70
Jan-80
Jan-90
Jan-00
Jan-10
Month-Year
Baker

Subsidence



Subsidence indicated from interferograms: April 1992 to December 1997

(Amelung et al, 1999)



Subsidence

at Well 5 in the Main Well Field

4 to 5 feet of land surface depression

LVVWD Well #5

Circ. 1990

PInSar
1996-2000
2000-2005

Bell and others, 2008

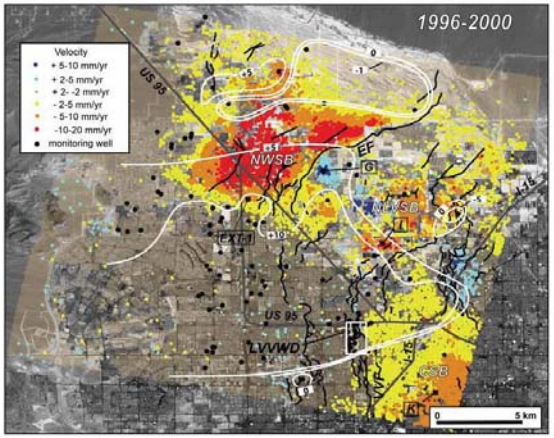


Figure 5b. Permanent scatterer velocity map from ERS data for the period 18 April 1996 to 28 April 2000 and water-level change for the period April 1996 to May 2000.

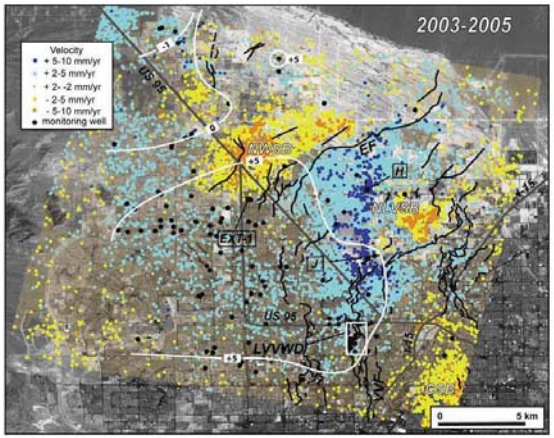


Figure 5c. Permanent scatterer velocity map from ENVISAT data for the period 18 April 2003 to 27 May 2005 and water-level change for the period April 2003 to May 2005.

Subsidence 2002 - 2004

Bell and Arai (2009)

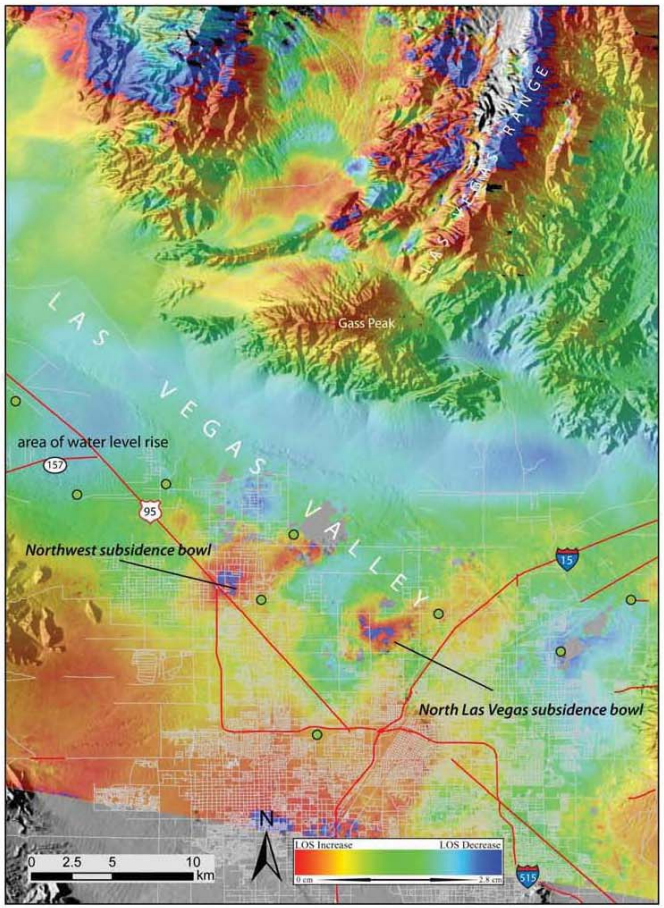


Figure 3b. Interferogram for northwest portion of Las Vegas Valley covering the time period 10/25/2002 to 12/3/2004. The Northwest and North Las Vegas subsidence bowls each show one full fringe (2.8 cm) of subsidence. An area of water level rise near the intersection of SR 157 and US 95 shows a possible partial up fringe signal (blue area), but this may be an atmospheric artifact. Monitoring wells shown by green circles.

Subsidence 2006 - 2007

Bell and Arai (2009)

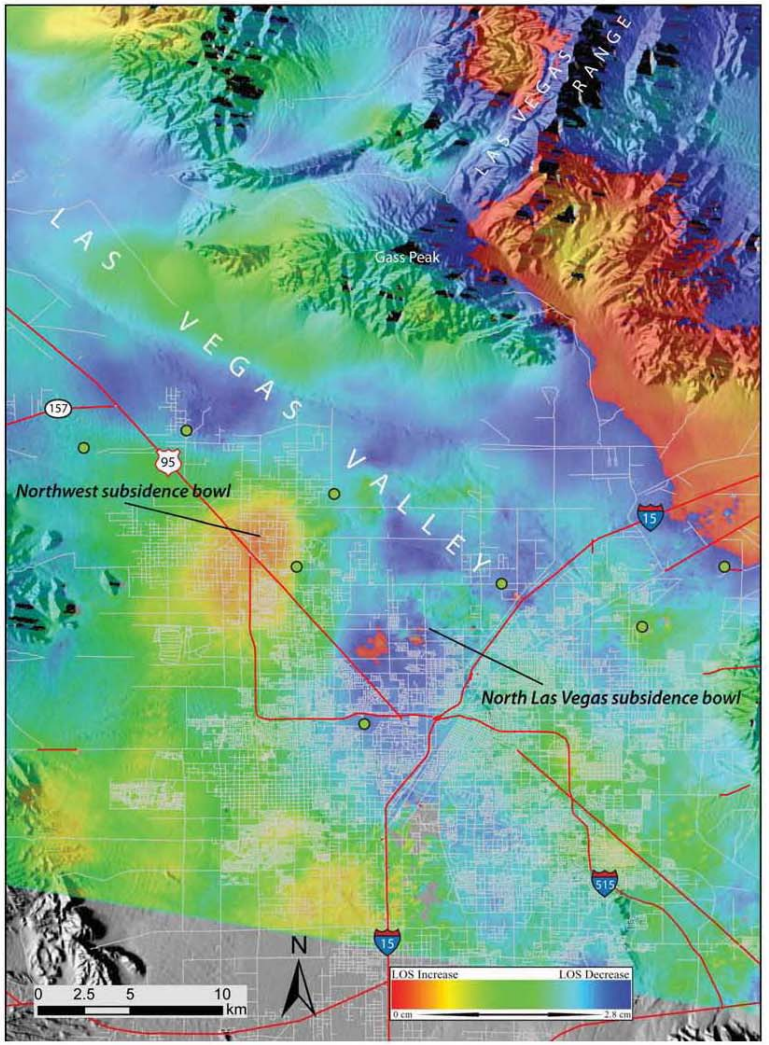
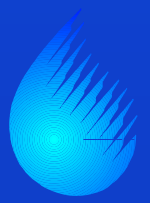


Figure 3d. Interferogram for northwest portion of Las Vegas Valley covering the time period 3/3/2006 to 4/27/2007. Subsidence rate has significantly decreased compared to earlier years. The Northwest subsidence bowl shows only a partial fringe (1-2 cm), and the North Las Vegas bowl shows a partial up fringe. The area of water level rise shows no visible signal. Monitoring wells shown by green circles.

Las Vegas Valley Subsidence

- Historic Changes Described by:
  - Bell (1981)
  - Bell et al. (1991)
  - Amelung et al. (1999)
  - Bell et al. (2008)
  - Donovan et al. (2008)
- Recent publications show strong links with the underlying geologic variations, introduction of new remote sensing techniques, and general slowing and reversal of historic trends



Additional Quantitative Analysis

- Snow Mountain Agreement
  - Beginning 2001
- “In-Lieu”
  - Beginning 2004

Monthly Volumes of Artificial Recharge Water 1987 - 2009

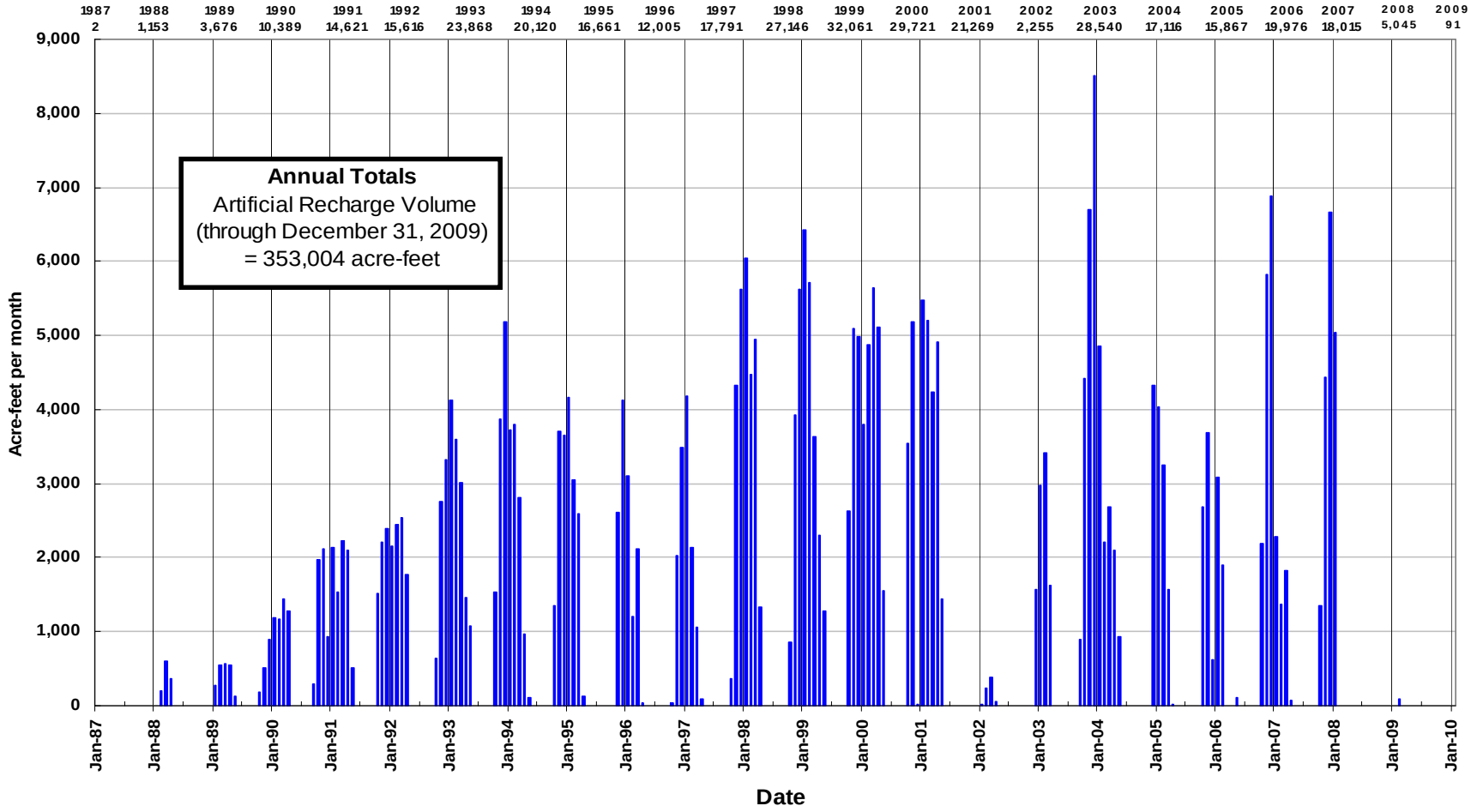


Table of LVVWD Groundwater Production and Artificial Recharge 1987 - 2009

Year	RECHARGE				PRODUCTION			
	LVVWD Colorado River Water Recharged	LVVWD In-Lieu Recharge Recoverable	LVVWD In-Lieu Recharge Unrecoverable	LVVWD In-Lieu Recharge Total	LVVWD Well Production	LVVWD Groundwater Rights	LVVWD Groundwater Recovery	LVPT Groundwater Recovery
1987	2	0	0	0	37,145	39,682	0	0
1988	1,153	0	0	0	37,096	39,772	0	0
1989	3,676	0	0	0	34,025	39,890	0	0
1990	10,389	0	0	0	33,925	39,920	0	0
1991	14,621	0	0	0	36,653	40,314	0	0
1992	15,616	0	0	0	39,937	40,314	0	0
1993	23,868	0	0	0	35,647	40,314	0	0
1994	20,120	0	0	0	37,907	40,314	0	0
1995	16,661	0	0	0	42,720	40,247	2,473	0
1996	12,005	0	0	0	41,543	39,947	1,596	0
1997	17,791	0	0	0	40,316	40,152	164	0
1998	27,146	0	0	0	39,857	40,126	0	0
1999	32,061	0	0	0	39,028	40,126	0	0
2000	29,721	0	0	0	38,255	40,126	0	0
2001	21,269	0	0	0	40,620	40,126	494	1,205
2002	2,255	0	0	0	41,218	40,126	1,092	1,178
2003	28,540	0	0	0	40,127	40,126	1	985
2004	17,116	0	0	0	40,877	40,612	265	664
2005	15,867	7,621	1,345	8,966	31,661	40,626	0	572
2006	19,976	4,064	717	4,781	35,845	40,626	0	815
2007	18,015	0	0	0	40,932	40,629	303	923
2008	5,045	0	0	0	40,671	40,629	42	809
2009	91	0	0	0	40,640	40,629	11	614
Total Artificial Recharge [1]:								
Totals:	353,004	11,685	2,062	13,747	886,645		6,441	7,765
Net Recoverable AR Storage [2]: 350,483								

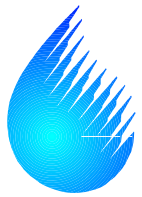


Table 2(revised): Annual well production, recharge, recovery and yearly totals since 1987.

	RECHARGE				North Las Vegas			PRODUCTION			
Year	LVVWD Colorado River Water Recharged	LVVWD In-Lieu Recharge Recoverable	LVVWD In-Lieu Recharge Unrecoverable	LVVWD In-Lieu Recharge Total	NLV Colorado River Water Recharged	NLV In-Lieu Recharge Total	NLV Well Production	LVVWD Well Production	LVVWD Groundwater Rights	LVVWD Groundwater Recovery	LVPT Groundwater Recovery
1987	2	0	0	0	0	0	0	37,145	39,682	0	0
1988	1,153	0	0	0	0	0	0	37,096	39,772	0	0
1989	3,676	0	0	0	0	0	0	34,025	39,890	0	0
1990	10,389	0	0	0	406	0	3,252	33,925	39,920	0	0
1991	14,621	0	0	0	1,447	0	4,312	36,653	40,314	0	0
1992	15,616	0	0	0	1,384	0	4,238	39,937	40,314	0	0
1993	23,868	0	0	0	667	0	4,592	35,647	40,314	0	0
1994	20,120	0	0	0	1,780	0	2,568	37,907	40,314	0	0
1995	16,661	0	0	0	2,511	0	3,345	42,720	40,247	2,473	0
1996	12,005	0	0	0	1,459	0	5,669	41,543	39,947	1,596	0
1997	17,791	0	0	0	1,134	0	5,614	40,316	40,152	164	0
1998	27,146	0	0	0	417	0	5,687	39,857	40,126	0	0
1999	32,061	0	0	0	300	0	4,135	39,028	40,126	0	0
2000	29,721	0	0	0	64	0	5,226	38,255	40,126	0	0
2001	21,269	0	0	0	107	0	5,449	40,620	40,126	494	1,205
2002	2,255	0	0	0	0	0	5,586	41,218	40,126	1,092	1,178
2003	28,540	0	0	0	167	0	4,878	40,127	40,126	1	985
2004	17,116	0	0	0	0	2,816	2,398	40,877	40,612	265	664
2005	15,867	7,621	1,345	8,966	0	3,414	1,694	31,661	40,626	0	572
2006	19,976	4,064	717	4,781	0	3,703	1,355	35,845	40,626	0	815
2007	18,015	0	0	0	0	4,218	749	40,932	40,629	303	923
2008	5,045	0	0	0	0	3,388	1,725	40,671	40,629	42	809
2009	91	0	0	0	0	3,570	1,511	40,640	40,629	11	614
Total Artificial Recharge [1]:											
Totals:	**353,004**	**11,685**	**2,062**	**13,747**	**11,843**	**21,109**	**73,983**	**886,645**		**6,441**	**7,765**
Net Recoverable AR Storage [2]: 350,483											

NOTES:

All volumes in acre-feet (af), (+/- 1 af due to rounding)

Yearly ground water rights reflect revisions per Las Vegas Basin Adjudication (1999)

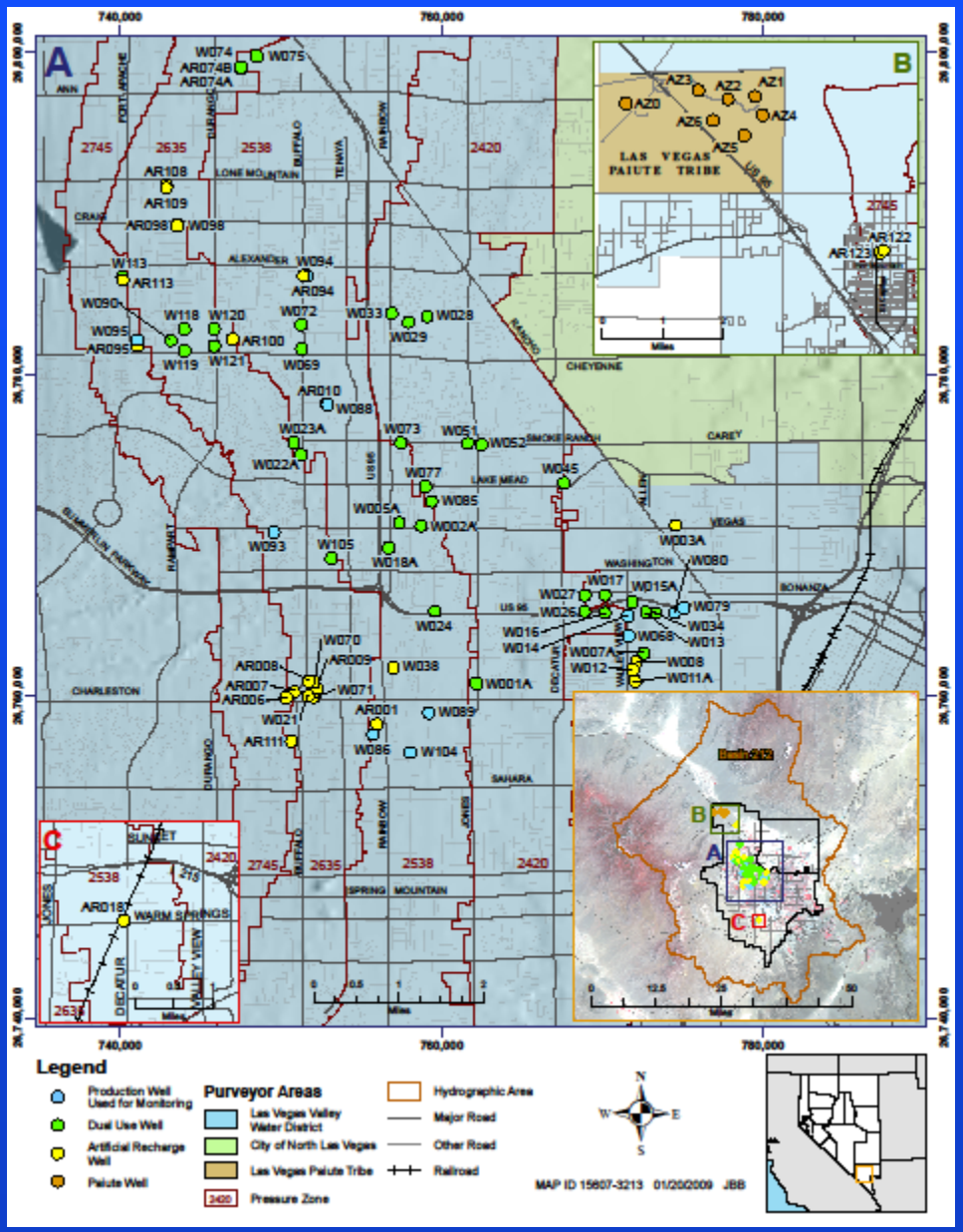
Las Vegas Paiute Tribe's temporary recovery of LVVWD-recharged water began in 2001

[1] LVVWD Total Colorado River Water Artificial Recharge

[2] Net Recoverable AR Storage = Total LVVWD CRW Recharged + LVVWD In-Lieu Recharge Recoverable - LVVWD Recovery - LVPT Recovery

Location of LVVWD wells used for artificial recharge and groundwater production

- Dedicated AR Wells
- Dual Use Wells
- Production Wells

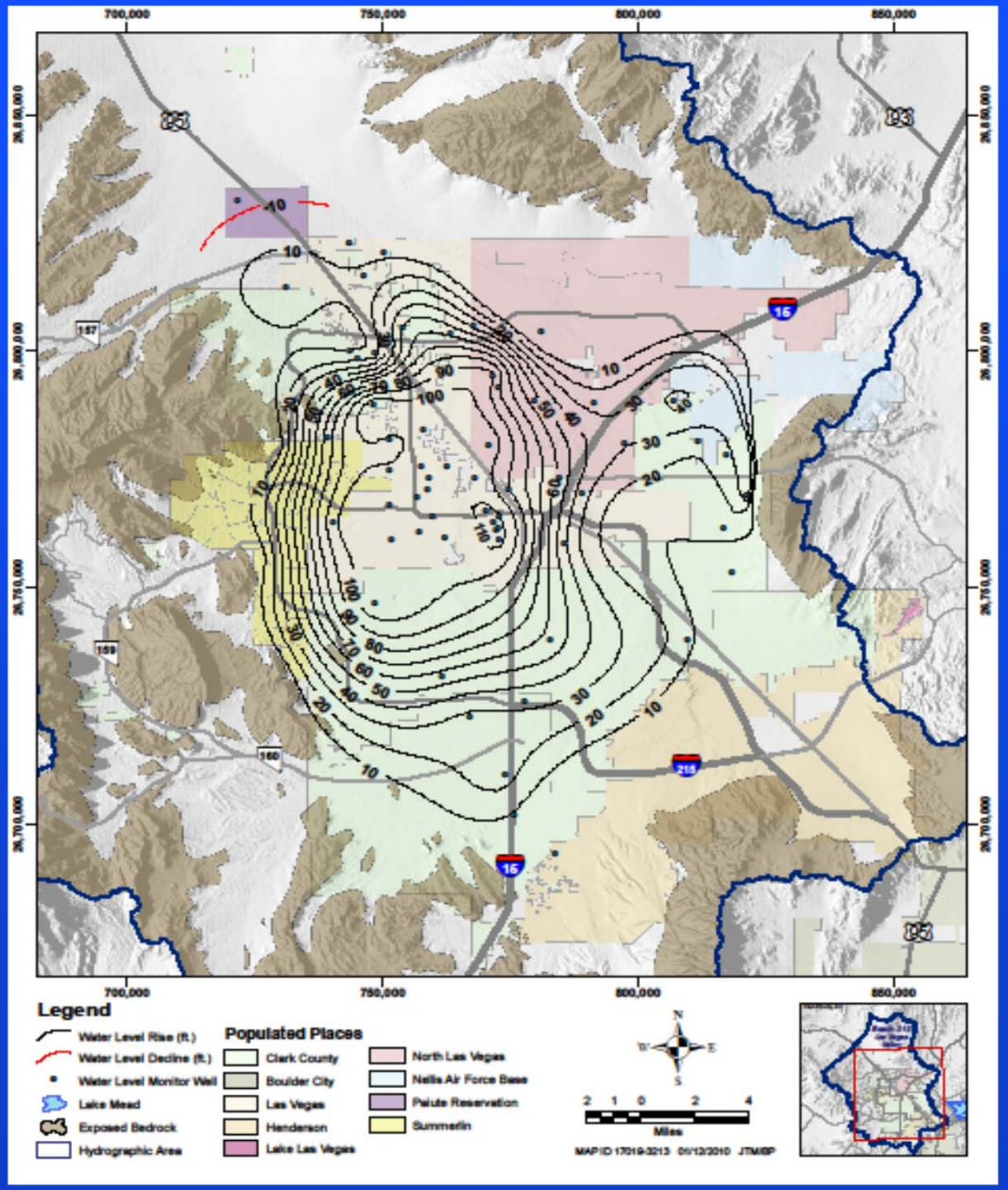


Effects of Artificial Recharge in the Las Vegas Valley

- Static Water Levels rising in the primary aquifer
  - Observed 10 to 100 feet rise in vicinity of AR
- Water Levels have been influenced throughout most of the Las Vegas Springs Aquifer
- Injected approx. 12,000 to 32,000 acre feet per recharge season since 1991, lesser amounts in recent years
- Banked 353,004 acre feet Net Volume of water through December 31, 2009

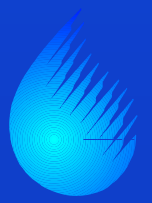
Change in Potentiometric Surface of the Las Vegas Valley Aquifer Fall 1990 – Fall 2009

Contour Interval=10 ft.



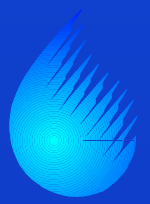
Benefits of Artificial Recharge

- **Provide an emergency supply in case of drought or a water facility failure**
- **Help meet summer peak demands and “bridge the gap” until future water resources become available**
- **Reduced pumping (electrical) cost**
- **Reverse declining water level trends (approximately 1/3 recovered)**
- **Minimize land subsidence and fissuring**



Geochemical Considerations For Artificial Recharge

- Suspended solids in injectate
- Microorganisms and biofouling
- Ion exchange and adsorption – clay mineralogy
- Reduction/oxidation processes
- Carbonate precipitation/dissolution
- Disinfection by-products
  - Leising, 2004



Geochemical Influences of AR

Leising (2004)

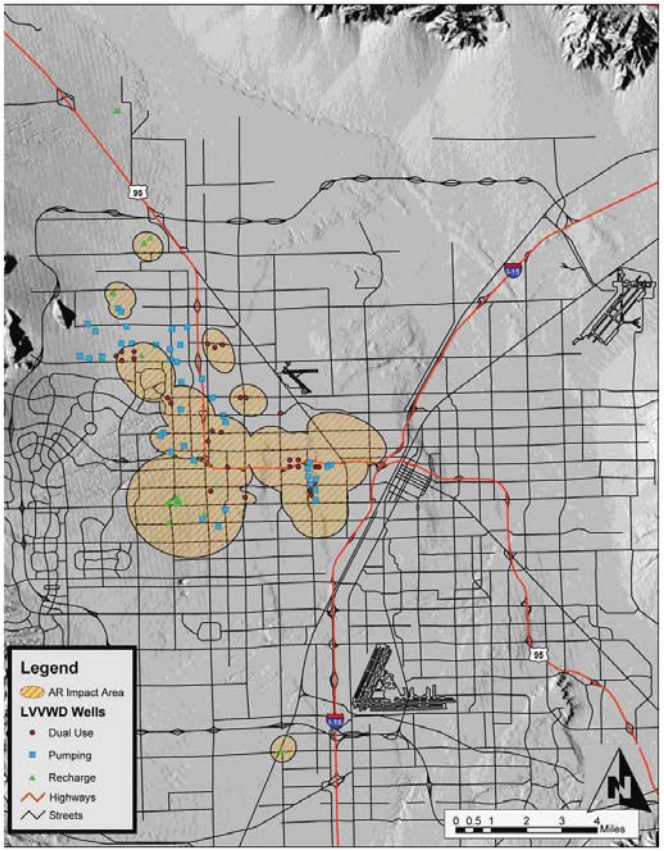


Figure 51. Areas with Greater Than 10% Artificial Recharge Water in Groundwater, Fall 2000.

Zones around artificial recharge sites determined using methodology discussed in the text and Appendix 6 assuming a thin (30 ft thick) aquifer. For three of the areas, distances were calibrated using field measurements. Others are consistent with water chemistry from producing wells. Total area within the overlapping ovals exceeds 16,000 acres, or ~26 square miles.

85

Well Construction Considerations

- Age of Well
- Method Of Construction
- Dual Use
- Paired Wells
- Single Purpose
- Currently 78 (District) Wells Permitted for AR

How Far Have We Come ?

Katzer and Brothers, 1989

cipal aquifer declined, the gradient reversed resulting in water from the shallow aquifer system percolating down to the principal aquifer. The shallow aquifer system generally contains naturally more mineralized water than does the principal aquifer. Water in the shallow aquifer system is further degraded by the application of fertilizers and pesticides to the landscape, which are then mobilized by overwatering, infiltrate through the root zone, and ultimately reach the water table. Changes in nitrate concentrations in water from wells completed in the principal aquifer (Figure 5) provide evidence that secondary recharge is reaching this aquifer. Fortunately the nitrate concentrations are considerably less than drinking-water standards and to date (1988) there has been no additional cost associated with this problem.

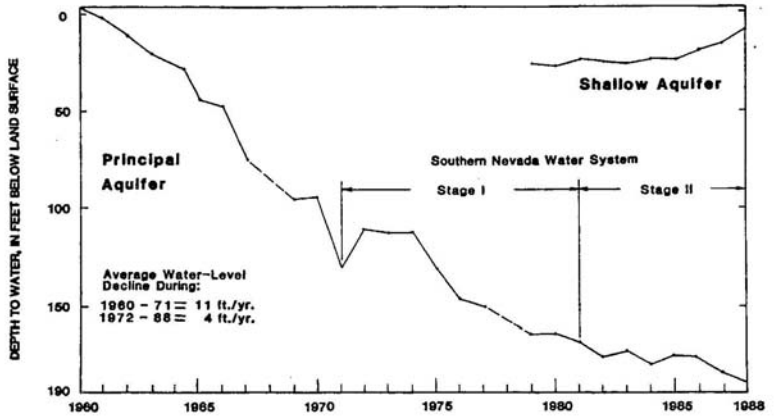


Figure 4. Hydrographs of Monitoring Wells.

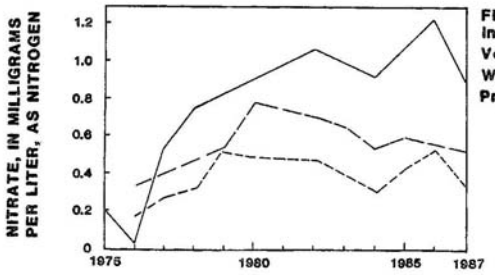
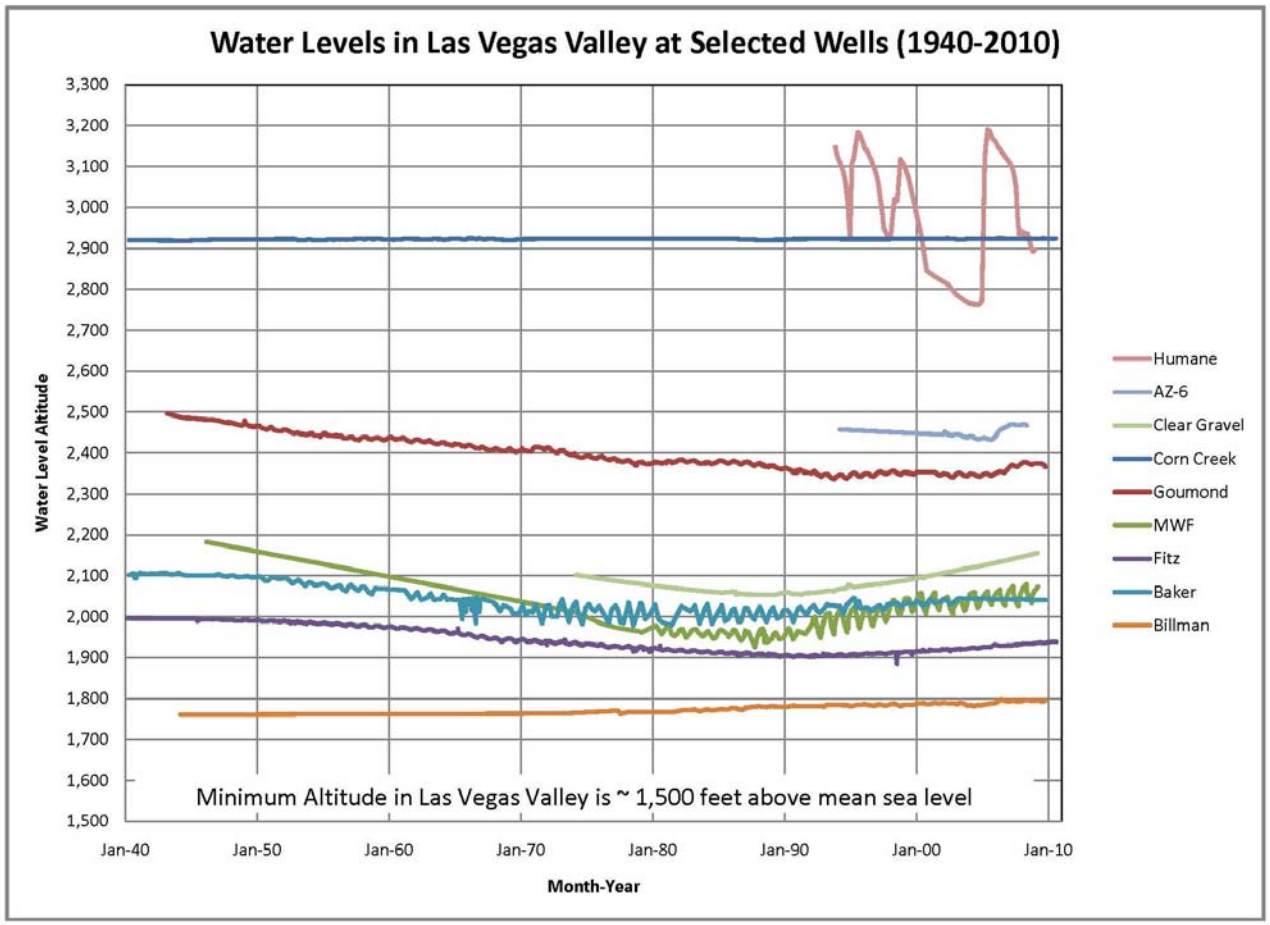


Figure 5. Nitrate Concentrations in Water from Selected Las Vegas Valley Water District Wells Pumping from the Principal Aquifer.


Water Levels in Las Vegas Valley at Selected Wells (1940-2010)
Water Level Altitude
3,300
3,200
3,100
3,000
2,900
2,800
2,700
2,600
2,500
2,400
2,300
2,200
2,100
2,000
1,900
1,800
1,700
1,600
1,500
Jan-40
Jan-50
Jan-60
Jan-70
Jan-80
Jan-90
Jan-00
Jan-10
Month-Year
Minimum Altitude in Las Vegas Valley is ~ 1,500 feet above mean sea level
Humane
AZ-6
Clear Gravel
Corn Creek
Goumond
MWF
Fitz
Baker
Billman

Key Points

- Aquifer response (water levels changes) are primarily determined by the natural plumbing of the hydrogeological system (sources, sinks and flow paths).

- The most accurate way to determine these factors is by careful analysis of the operational changes