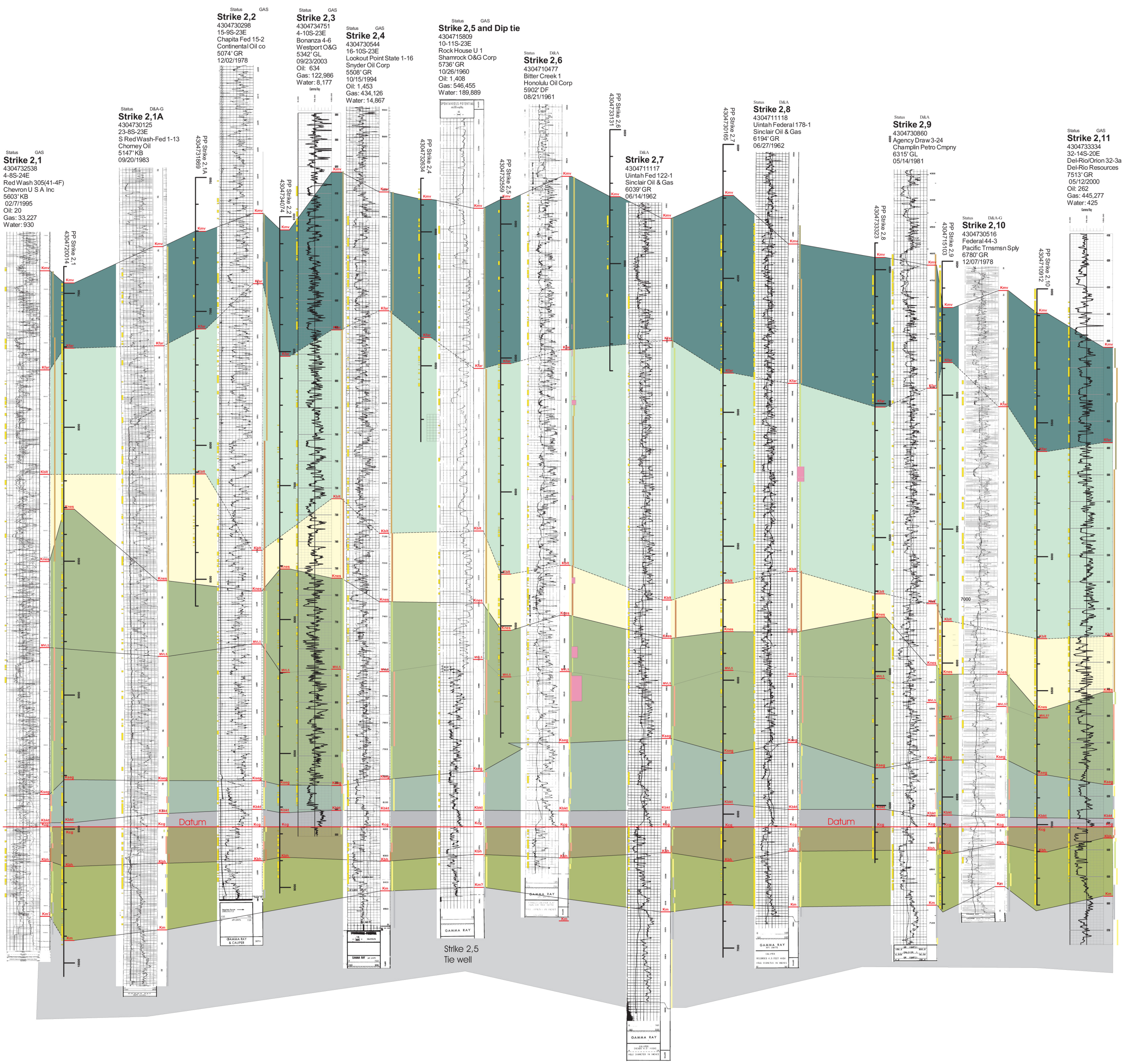
MESAVERDE GAS OF SOUTHEASTERN UINTA BASIN

by Paul B. Anderson



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by

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1.0 Introduction

The Mesaverde Group has become one of the chief producers of gas in the Uinta basin. The Mesaverde Group of formations varies across the basin from west to east. On the west or depositionally landward side, the Mesaverde Group consists of the Blackhawk Formation, Castlegate Sandstone, Price River Formation. On the east the group consists of the Blackhawk Formation, Castlegate Sandstone, Buck Tongue of the Mancos Shale, Sego Sandstone, Neslen Formation, Farrer Formation, and Tuscher Formation (Fouch and others, 1992). Gas is produced from chiefly sandstone reservoir rock throughout the stratigraphic section.

Many operators have drilled or have wells permitted to drill to this objective. Gas from the Mesaverde in the interior of the Uinta basin appears to fit a basin-centered gas model. Limited conventional traps occur at shallower depths, along the basin margin. Exploration trends have been away from established production in the Natural Buttes field (east-central part of the basin), attempting to find the limits to this prolific reservoir. To date, most exploration has been chiefly in an up depositional dip (west to northwest) or depositional strike-parallel (northeast to southwest) direction. The attached figures helps to illustrate where drilling into the Mesaverde objective has occurred.

This work is built on the excellent work of many previous authors who have published their work in local geological association guidebooks and more recently, in federally funded work by the USGS and National Energy Technology Laboratory (NETL). The objective of the study is to bring together information from drilling in the play that aids both the Utah Geological Survey (UGS) and operators to better understand the play, its reservoirs and potential new reservoirs, and drilling and production trends. The study uses about 75 wells which fall along or near three cross sections through the area. One running along depositional dip and two along depositional strike. The cross sections consist of 30 wells with gamma ray traces which penetrate most or all of the Mesaverde and about another 22 wells represented as vertical lines on the sections and generally only penetrating part of the Mesaverde. The cross sections contain formational contacts, depositional facies, DST tested intervals with results, Ro values (where available), and net sand.

Production is depicted on maps at 1:100,000 scale showing cumulative and IP information. These maps are generated from the cross section wells and at least one well per section throughout the entire study area. Because many Mesaverde completions are commingled with Wasatch zones, these wells have a percent net Mesaverde perforations indicator on the accompanying maps to help estimate the influence of the two completion zones (Wasatch and Mesaverde).

Structure contour and an isopach map of the Mesaverde from all available data is included. Data for these maps are from previous published studies, UGS, and DOGM website. To visually tract where the play is headed and how it has developed historically, ten small scale maps are included which show wells with Mesaverde completions by decade beginning in 1960. (No Mesaverde wells with historic production were drilled prior to 1960.)

2.0 Technical Discussion

2.1 Objective

The objective of the study is to improve the characterization of the Mesaverde (Kmv) gas play and gain a better understanding of the trapping mechanisms by providing a stratigraphic picture of the productive horizons, depositional environments, and stratigraphic units of this important gas play, and to map production trends in three dimensions. The cross section lines are purposely extended out beyond the areas of high drilling density to encourage extension of the play.

2.2 Methods

Only a portion of the wells within the Mesaverde play in the Uinta basin were examined in detail. These wells lie along the cross section lines or near them. A few other selected wells away from the cross section line were examined and tops incorporated. Data on tops were gathered from the Division of Oil, Gas, and Mining website, UGS, USGS (various publications), and any other published source. The production data base was used based on a December 31, 2004 cutoff.

Digital log files for the cross sections came from the Division of Oil, Gas, and Mining website, UGS, and cooperative operators (LAS format). Reservoir features such as net sand, and depositional environments are located on the cross sections for all the full penetrating logs of the Mesaverde. Net sand logs were made using the gamma-ray log and SP if no gamma log was available. An API cutoff value of 60 was used in most cases. The exceptions are noted on the cross sections. Some gamma logs appeared to be of considerable difference in scale to offsets and adjusted to better represent net sand. SP logs were used but should be considered a poor representation of net sand.

Contour maps served as a method to find corrupt tops. In very few cases were "bad tops" investigated by examining the logs. In most cases a top that appeared to be way out of range of the surrounding wells was simply deleted. The isopach of the Mesaverde was edited in a similar way to the structure map and bad points which were not on the cross sections lines were eliminated rather than researched due to funding limitations. Contouring was performed with *Surfer*® using the kriging algorithm. Data was distributed throughout the area, although not with equal density. The western edge of the map does portray some "edge effects" from the contouring software.

Wasatch-Mesaverde commingled production has created a host of problems, mainly in the production and test reporting. Wells from the Division of Oil, Gas, and Mining (DOGM) production database which are listed as commingled Wasatch-Mesaverde producers were compared to the tops database to weed out wells which never encountered the Mesaverde.

Scores of wells were dropped from the list when the two lists were compared. Unfortunately a portion of the wells which have penetrated the Mesaverde in the area have no tops recorded in the DOGM database, so this is not an effective means to weed all of the non-commingled wells which are incorrectly listed as commingled from the DOGM database. In reviewing the perforations for the commingled wells, many were found to be perforated only in one formation or the other. These wells were dropped from the "commingled list." Sometimes the well had a legitimate initial production (IP) commingled test but when subsequent production tests were run, zones within or the entire Mesaverde were squeezed off or a bridge plug set, changing the condition of the well from a commingled producer to either a Wasatch or Mesaverde producer. This has resulted in a much reduced number of Wasatch-Mesaverde production than indicated in the Division of Oil, Gas, and Mining's database. Net perforations were calculated based on reported intervals of perforations. The detail of these reports varies as does the reliability of these data. They are presented on the maps of both IP tests and cumulative production for the commingled wells and the modified production database is included on the CD. The cumulative production bubble map for the Mesaverde only producers does not include wells which had zero gas production but did produce oil.

Depositional environments were assigned based on log character and published interpretations. All interpretations are the responsibility of the author but these interpretations were made with due consideration of other published sources. Designations in the Castlegate, Blackhawk, and Sego were given a disproportionally greater emphasis.

3.0 Results

Table 1 lists the wells used in the construction of the three cross sections. The sections are labeled Dip, Strike 1 and Strike 2 (Plates 1-3); indicating their approximate relation to the depositional dip and strike of the Mesaverde, with Strike 1 located on the west of the area and Strike 2 located on the east or more seaward side. The wells listed as PP are "partial penetrators," meaning they did not drill the entire thickness of the Mesaverde (with a couple of exceptions) and the logs of the wells are not posted to the cross section but a stick log showing tops, net sand, and DSTs are on the cross sections.

The results of the work are presented in a series of maps and cross sections listed below and found attached as pdf files. The three colored geologic cross sections are at a vertical scale of 1 inch =100 feet and a horizontal scale of 1" = 7175 feet. There are two pdf files of each cross section. The "full" series shows more of the logs in the sections at the top and bottom of the sections. The "plot" series has truncated the tops and bottoms of a few logs on each sections in order to fit to a 42" wide plotter and maintain the vertical scale of 1inch =100 feet. The file names are as follows:

Plate 1 (Dip) cross section_full
Plate 2 (Strike 1) cross section_full
Plate 3 (Strike 2) cross section_full

Plate 1 (Dip) cross section_plot
Plate 2 (Strike 1) cross section_plot
Plate 3 (Strike 2) cross section_plot

The maps at 1:100,000 are also found on this CD with the following file names:

Map 1_Structure contour top Kmv.
Map 2_Isopach Kmv.
Map 3_Cumulative production Kmv wells.
Map 4_Cumulative production Wasatch-Mesaverde wells
Map 5_IP Kmv wells
Map 6_IP commingled Wasatch-Mesaverde wells

11 x 17 inch (tabloid size) maps found on the CD with the following file names:

Map 7_Kmv productive completions 1960
Map 8_Map 7_Kmv productive completions 1970
Map 9_Kmv productive completions 1980
Map 10_Kmv productive completions 1990
Map 11_Kmv productive completions 2000_2004
Map 12_Wasatch&Mesaverde productive completions 1960
Map 13_Wasatch&Mesaverde productive completions 1970
Map 14_Wasatch&Mesaverde productive completions 1980
Map 15_Wasatch&Mesaverde productive completions 1990
Map 16_Wasatch&Mesaverde productive completions 2000_2004

3.1 Stratigraphy

Trends in the nature and thickness of the Mesaverde Group have been recently summarized by Hettinger and Kirschbaum (2003, 2002), Johnson (2003), Johnson and Roberts (2003) and earlier in Fouch and others (1992). These references lead to a long list of previous work in the basin on the Mesaverde section.

3.1.1. Blackhawk Formation. The basal contact with the Mancos Shale is a problematic pick in logs because only when a great thickness of the shale has been penetrated can one be confident that a sandy tongue of the overlying Blackhawk Formation does not lie below the total depth (TD) of the well. The contact is lithostratigraphic in nature and through the dip section in particular, traverses many time lines. Wells were selected for the cross sections based on complete penetration of the Mesaverde, but when correlated to other deeper penetration wells, the Mancos top was only a tongue with addition sands of the Blackhawk likely below the TD. Plate 1 clearly shows the thinning of the Blackhawk eastward into the Mancos Shale. This thinning incorporates all facies of the Blackhawk, both the rich source rocks of coals and carbonaceous shales and excellent reservoir shoreline and fluvial sandstones. The thinning into a good source rock (Mancos Shale) at depths well within the hydrocarbon generation window along the western parts of the Dip section (plate 1) (Nuccio and others, 1992) make for an excellent exploration play in the Blackhawk. This prospective zone runs parallel to the Strike 1 cross sectional line from Dip 1 to Dip 2 wells, a wide fairway. Several companies are drilling this trend with encouraging results.

3.1.2. Castlegate Sandstone. The Castlegate Sandstone is used as the datum for the three cross sections (plates 1-3). The basal contact with the Blackhawk Formation has been described by Van Wagoner (1995) as an unconformity. Van Wagoner's cross section (1995) shows fluvial downcutting into the Blackhawk until just short of the seaward pinchout of shoreline facies genetically associated with Blackhawk progradations but stratigraphically called Castlegate. Hettinger and Kirschbaum (2002) show a similar picture with the erosional unconformity placing fluvial Castlegate facies on marine Blackhawk near the eastern end of the unconformity. Cole and others (2001) see a similar unconformity but have interpreted the facies in the Castlegate at the seaward end of the unconformity as transitional from fluvial, estuarine, to deltaic. I have followed their interpretation as the Castlegate thins in the eastern end of the Dip section.

The Castlegate Sandstone began as a member of the Price River Formation but has evolved to formational status (Hintze, 1988). Subsequently, Hettinger and Kirschbaum (2002) describe the complexities of the "new" Castlegate Sandstone which includes rocks of the Bluecastle Tongue or sandstone as the upper informal member. In Price Canyon the Bluecastle Tongue or sandstone was formally part of the Price River Formation (Clark, 1928). The USGS (2003) refers to this upper sandy member as the "upper Castlegate" sandstone in their data base. The Bluecastle Tongue is picked on the accompanying sections, but the unit is either not properly picked or has poor lateral continuity in the subsurface. The contact lines on the sections are dashed indicating poor correlation (plates 1-3). Difficulty in mapping the Bluecastle (or top of the "new" Castlegate) in the subsurface in this study has led to use of the top of the Castlegate as that originally defined in Price Canyon or the "lower" Castlegate of USGS DDS-69-B.

The environment of deposition of the Castlegate Sandstone changes from a braided stream deposit (on the west, in Price Canyon) into shale-rich lower coastal-plain and marginal-marine rocks (on the east side of the Green River) and may provide a permeability baffle or barrier to eastward migration of gas. This barrier could create a "sweet spot" for gas production. The transition takes place between wells Dip 4 and Dip 6 on plate 1. This path of gas migration and its alignment with the depositional strike should be most prospective in the northeastern part of the study area, where the structural orientation of the basin is parallel to sub-parallel with the depositional strike.

3.1.3. Buck Tongue. The Buck Tongue of the Mancos Shale was mapped as part of the Mesaverde Group in this study. The unit overlies the Castlegate Sandstone in central to eastern portion of the study area. The most landward portion of this marine transgression is found in the Dip 4 well (plate 1). Dip 2 has a classic upward decreasing gamma-ray trace above the Castlegate which could be interpreted as marine. The environment of deposition was left as coastal-plain because of the two down depositional dip wells, which have no distinct log indication of marine deposition for the same interval. Strike 1 cross section has thin and laterally inconsistent occurrences of the Buck Tongue, indicating its location and orientation near the landward edge of the facies. Either these thin shales are incorrectly interpreted as marine or the orientation of the shoreline was not straight. The more seaward cross section Strike 2, plate

3, has Buck Tongue present along its entire length.

3.1.4. Sego Sandstone. Above the Buck Tongue of the Mancos Shale is the Sego Sandstone. Fisher (1936) originally described the Sego in Sego Canyon, Utah (T19S, R20E). Willis (1986) describes the unit as 127 feet thick and consisting of three informal members, mappable by upward transitions from shale to sandstone, with no coal. Similar upward coarsening deltaic sequences in the Sego are noted in well Strike 2,8 (plate 3). Other wells in the sections in the Sego show similar log characteristics, but often only one or two cycles can be distinctly identified. Other workers (Van Wagoner and others, 1990, and Hettinger and Kirschbaum, 2002) have identified up to 9 marine cycles or sequences in the Sego in outcrop and wells in eastern Utah. The Sego loses its distinctive marine characteristics and passes into marginal marine to coastal-plain facies in the western half of the Dip section (plate 1). To the east, the marine shale between deltaic shoreline deposits thicken, as the unit eventually pinches out into the Mancos in Colorado. Sego fully developed (upper shoreface-foreshore) deltaic sands along with heterogeneous fluvial and tidal sands offer good but spotty reservoir rock potential.

3.1.5. Neslen Formation. The Neslen Formation, as described on outcrop in the Book Cliffs of eastern Utah (Willis, 1986) does not correlate well in the subsurface. On outcrop the formation is described as 143 feet thick in the Sego Canyon area. Work by MacMillan and others (2003) have the Neslen top about 800 feet above the Castlegate Sandstone. This thickness includes the Sego, where it is distinctly defined and equivalent non-marine rocks to the west. In this study the Neslen top was picked where low density/high resistivity, carbonaceous shales and thin coals produce a distinctive log signature below the more sand dominated Farrer/Bluecastle. This top is approximately equal to the MVU33 top of MacMillan and others (2003).

Within the Neslen, is one of the better marker zones in the lower Mesaverde. The zone is distinctive in its lack of coal or carbonaceous shales and MacMillan and others (2003) mark the top of this zone as MVL5. This designation is posted for this zone on all the cross sections (plates 1-3). In well Strike 2,10 (plate 3) the zone was thin or indistinct and the only cross section well in which the zone was not identified was well Dip 1, on the westernmost edge of the study area. The zone has an approximate average thickness of 250 feet and is interpreted as a marginal-marine facies, perhaps associated with a marine transgression, time equivalent to the Corcoran/Cozzette section of western Colorado. Hettinger and Kirshbaum (2002) noted widely correlatable estuarine facies in the Neslen in their cross section. The MVL5 zone may be these same rocks. Below this marker zone is a series of coal-bearing and carbonaceous lower coastal-plain rocks about 100 to 200 feet thick, directly above the Sego Sandstone (where present) or the Castlegate Sandstone.

3.1.6. Bluecastle Tongue. Bluecastle Tongue of the Castlegate Sandstone was originally named by Fisher and others (1960) from exposures in the eastern Book Cliffs along the Utah-Colorado border. The cross sections have picks for this top in most wells but the correlation is sometimes strong from well to well, but rarely strong across the entire cross section. This top and formational boundary is therefore dashed. Some of the thickness variations in the underlying upper part of the Neslen are likely related to changes in the thickness and occurrence of the erosional based Bluecastle Sandstone. The top of the Bluecastle was more often than not, a very difficult pick. The overlying Farrer is contains many channel sands. Examination of the gamma-ray traces on the cross sections illustrates the difficult nature of the top of the Bluecaslte. Franczyk and others (1990) note the absence of the Bluecastle in measured sections east of Green River, Utah and the difficulty in picking the top of the Neslen-base of the Farrer.

3.1.7. Farrer Formation. Farrer Formation is here separated from the overlying Tuscher Formation but with little confidence. The contact is dashed to indicate the tentative nature. The tentative contact moves up and down through the section without much correlation to other contact lines. There is a zone in the upper Mesaverde in Dip section wells 6-9 that has reduced sand content, thinner sands, and the shales are slightly lower resistivity. On sonic logs this upper Mesaverde often contains shales with faster sonic velocity, interpreted as less carbonaceous than the section below. The problem with most picks that are comfortable for a few wells run into problems when correlating through the entire cross section. Franczyk and others (1990) and MacMillan and others (2003) abandoned the division between the Tuscher and Farrer and this study confirms others feel the lack of utility in forcing a division of the two units.

3.1.8. Tuscher Formation-Mesaverde top. The top of the Mesaverde pick should lie along an unconformity, marked in the southeastern portion of the Unita basin by the Dark Canyon sequence (Franczyk and others, 1990). This is a series of beds or one bed of conglomerate up to 150 feet thick on outcrop. Flow direction of these braided-stream deposits was to the northwest off the Uncompahgre uplift. MacMillan and others (2003) identified a sequence of rock about 100 feet thick at the base of the Wasatch Formation and proposed the name "Dark Canyon Formation." In their type log (Federal #22-1, 22-9S-20E) the Dark Canyon Formation consists of two, 25 to 30 foot thick low gamma-ray count uints, presumably conglomerate or sandstone. They place the top of the Mesaverde at the base of the lower low gamma-ray count unit. This boundary marks a change to slightly lower conductivity in the Mesaverde and "spiky" high resistivity related to thin coaly and carbonaceous material. On a sonic log, the Dark Canyon beds typically show a gradual reduction in velocity downward in each bed. When a mud log is available, the Mesaverde top is typically marked by a loss of red shale and the beginning of carbonaceous material.

3.1.9. Mesaverde Isopach. With all this said, the Mesaverde top is still challenging to pick in many wells, and a flat surface at the contact is certainly not expected. Map 1, the structure contour map of the top of the Mesaverde shows some variations across the area. Map 2, the isopach for the Mesaverde is perhaps a better illustration of the collective irregularities in the thickness of the unit. With a basal contact which is lithostratigraphic and an upper contact which is erosional, and a variety of geologists making the pick, it is not surprising to see the variation in thickness on Map 2. To generate Map 2, 200 wells were used with an average thickness of 2,543 feet, a maximum thickness of 3,465 feet and minimum of 1,785 feet. The standard deviation is 330 feet. Considering the lack of control on the picks in the database, the average is probably the most reliable number of the above statistics.

3.2 Production Trends

The Mesaverde (Group) averages about 2,500 feet thick in the study area, making it challenging to understand all of the aspects of the play. To adequately characterize the geology, production trends, and future potential of such a thick stratigraphic section and not over-generalize is difficult. Cumulative production and IP trends in the Mesaverde do not correlate (see graph 1). Although production from the deeper portions of the Mesaverde are a relatively new development, historically the stratigraphic position (upper versus lower, versus middle) of completion within the Mesaverde shows no distinct trend (see graph 2). There is a hint of a positive relationship between better cumulative gas with increase in stratigraphic depth (graph 3). This trend is very tenuous, considering how few data points are available for the deeper penetrations and how relatively new a Mesaverde only completion is within the area. Depth of the Mesaverde top and IP are poorly correlated, but graph 4 indicates a trend towards decreasing IP with depth. More net footage perforated does not net an increase in the IP (graph 5).

Map 3 shows in interesting increase in the production of oil and decrease in gas from the Mesaverde in the middle of Township 9 South, Range 22 East. Map 4 indicates that increased net perforations from the Mesaverde in commingled Wasatch-Mesaverde producing wells has not lead to better producers.

The lowest part of the Mesaverde within the Blackhawk Formation provides exciting potential. Aerially large shoreline sand deposits pinch out into the Mancos Shale to the east. In the eastern part of the basin, east of Range 19 East, the orientation of the shoreline pinchouts and the structural strike favor a stratigraphic trap. Research in the last ten years has shown that many of these large shoreline sheet sands are cut by incising fluvial systems. The fluvial sands are more heterogeneous in nature and could create a baffle and in some cases a barrier to gas flow as it migrates updip to the south in the basin. Areas west of Range 20 East and south of Township 7 South, and aligned with potential shoreline pinchouts have additional potential in the lower Mesaverde (Blackhawk).

Facies changes in the middle Mesaverde have been mapped by the USGS and provide additional trends for potential up dip change in facies from more porous and permeable fluvial meander belts to very heterogeneous coastal-plain facies. This facies transition area provides an opportunity for trapping gas in the sandier meanderbelt facies where the structural orientation of the Uinta basin is aligned with the pinchout trend. The pinchout of sand in the Castlegate interval appears to have the best alignment with the structure of the basin. This prospective area is similar to that described for the Blackhawk shoreline trends.

With the exception of the lower Blackhawk and Sego Sandstone, most of the Mesaverde play is in fluvial reservoirs. Predictability of these ancient fluvial reservoirs location and quality is still challenging the exploration geologist. That's the bad news, but this inherent variability provides many opportunities for serendipitous encounters between the drill bit and good gas-filled reservoirs through a 2 to 3 thousand foot section. This section of rock contains considerable carbonaceous material and some coal beds which are the source of the gas. Similar rocks in the Piceance Basin in western Colorado are being drilled on 10 acre spacing. Operators are not attempting to chase individual channel sandstones. The thick stratigraphic section, the large productive interval, and the inherent variability of any individual channel sand have defied predictability but not exploitation.

3.3 Database

Well database containing well name, operator, API, UTM location, T&R location, reference elevation, and all associated data gathered during the project for each well is attached as the "Kmv UGS study database.xls." Please note that this file has two tabs or worksheets, one for the full penetrating wells and one for partial penetrating wells. In addition, the modified production statistics derived from the Utah State Division of Oil, Gas, and Mining and modified to better reflect the correct production zone is included as Kmv UGS study production.xls.

4.0 Acknowledgments

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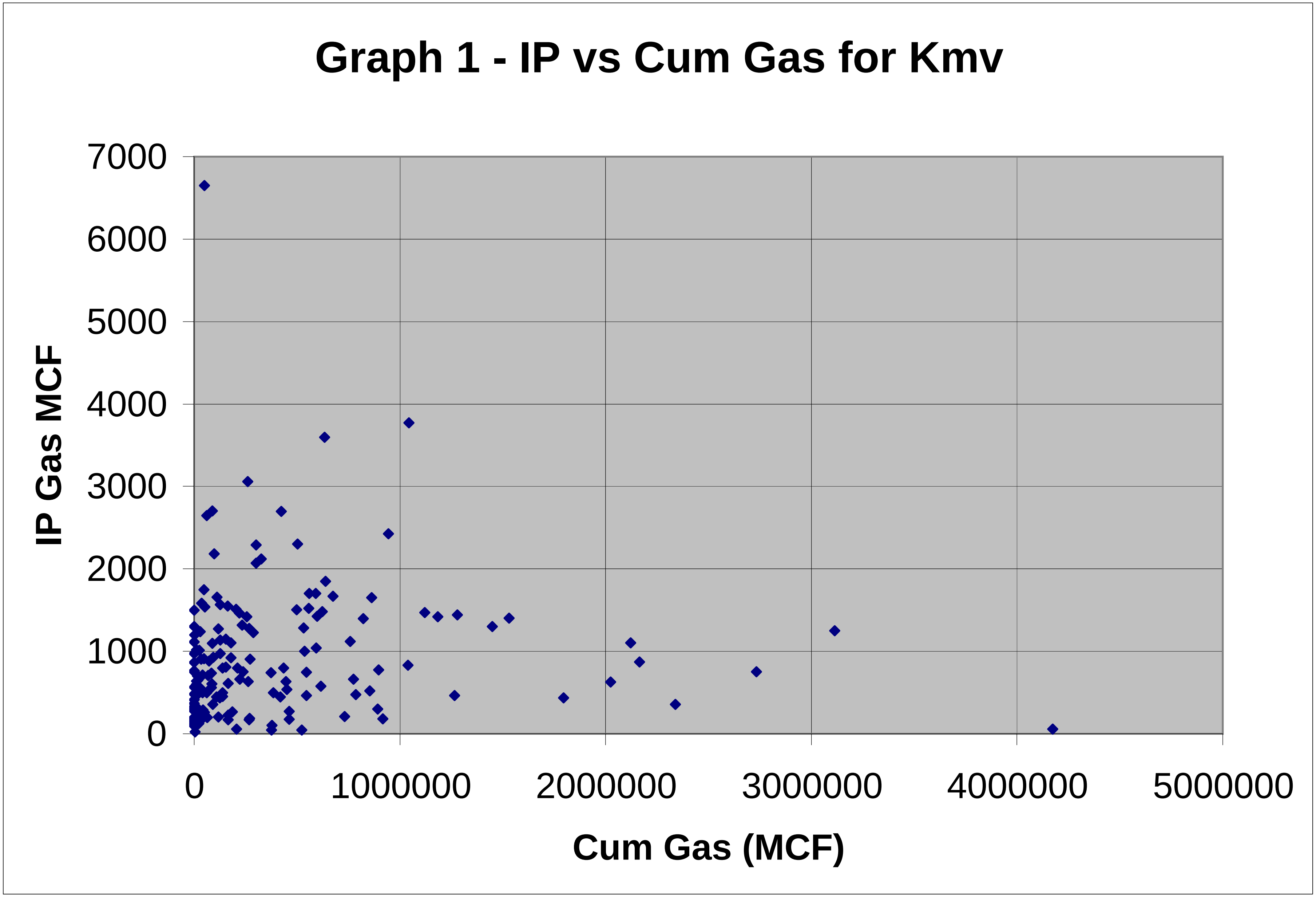
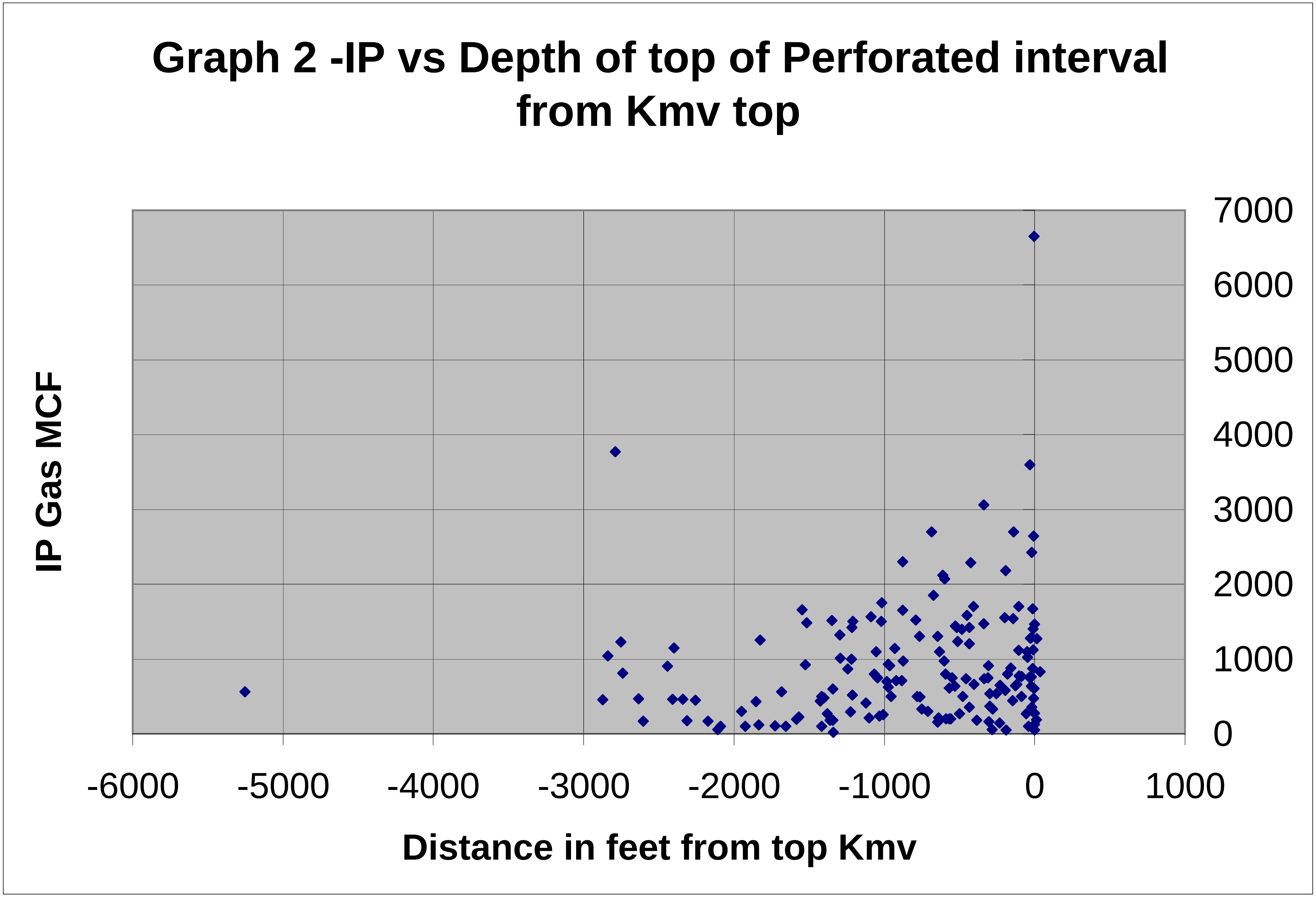
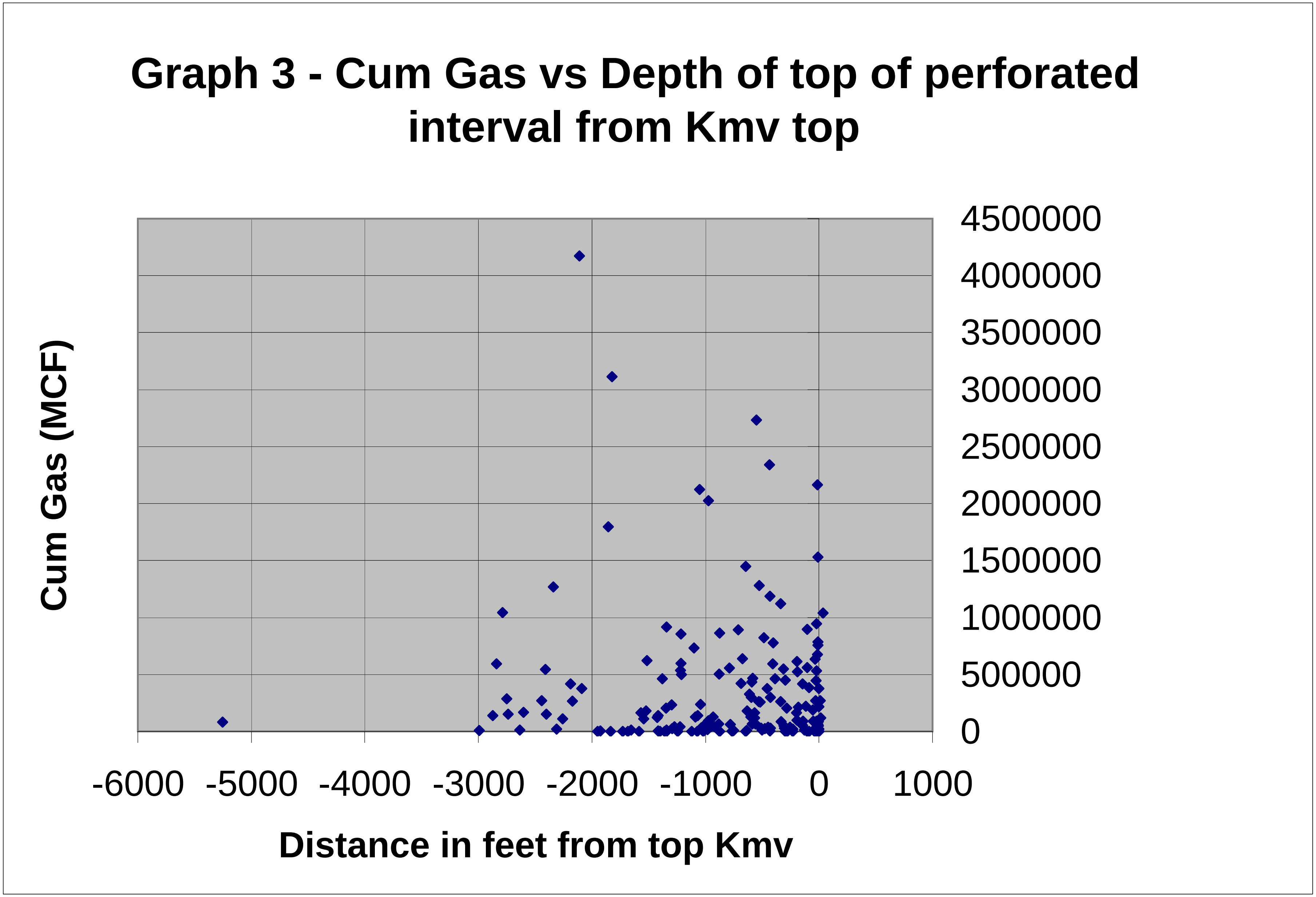
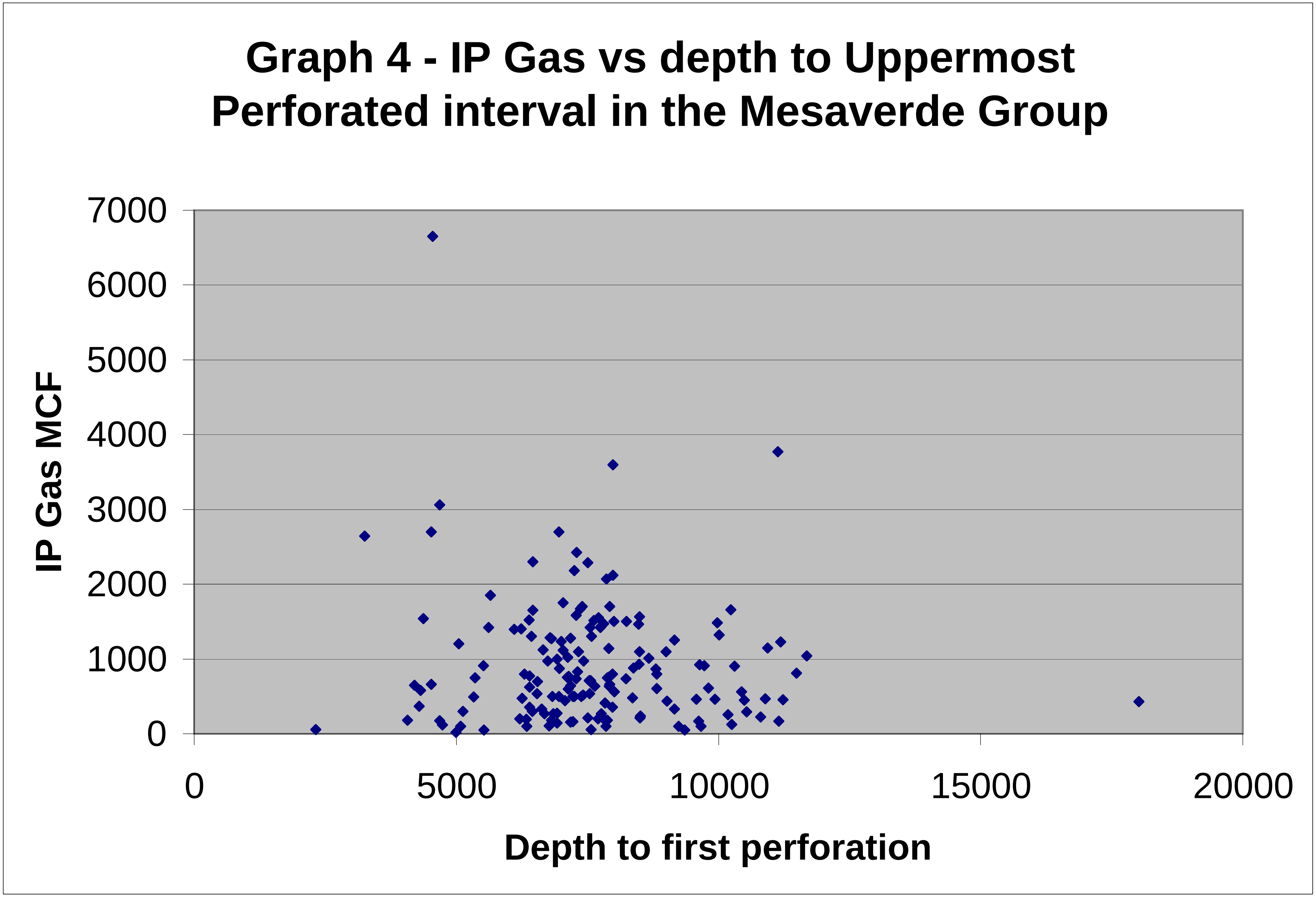
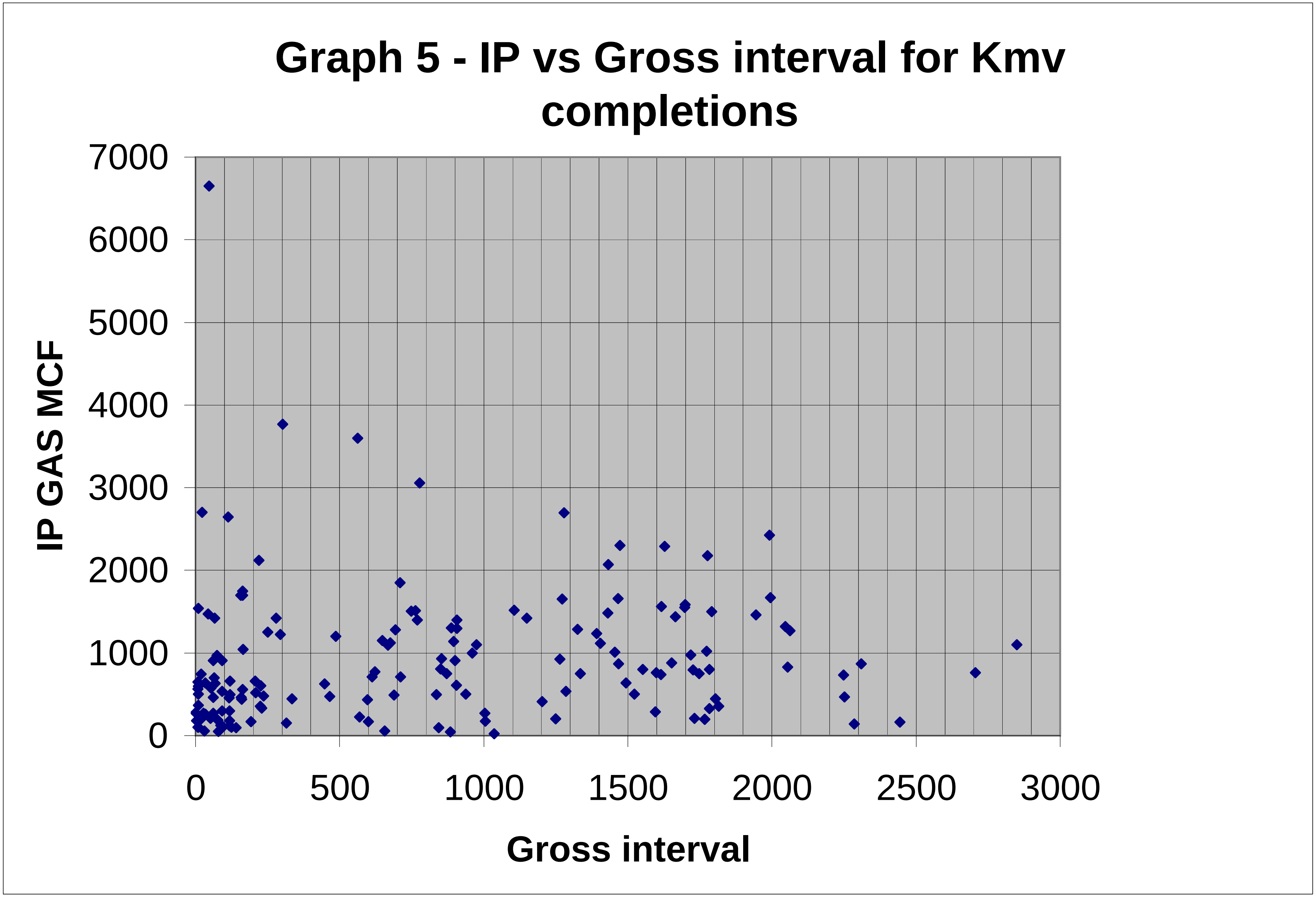

Graph 1 - IP vs Cum Gas for Kmv
IP Gas MCF
7000
6000
5000
4000
3000
2000
1000
0
0
1000000
2000000
3000000
4000000
5000000
Cum Gas (MCF)

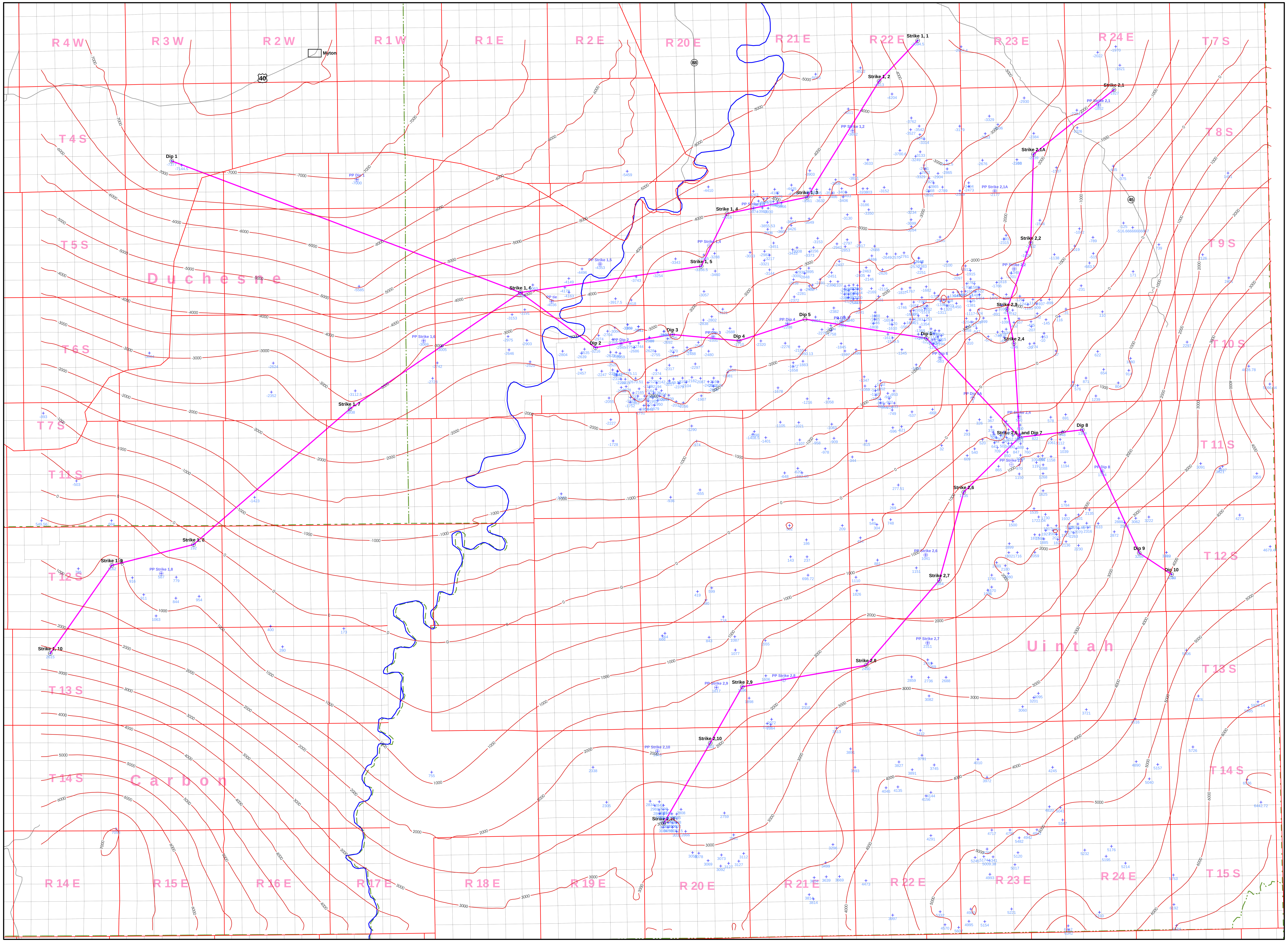

Graph 2 -IP vs Depth of top of Perforated interval
from Kmv top
IP Gas MCF
7000
6000
5000
4000
3000
2000
1000
0
-6000
-5000
-4000
-3000
-2000
-1000
0
1000
Distance in feet from top Kmv


Graph 3 - Cum Gas vs Depth of top of perforated interval from Kmv top
Cum Gas (MCF)
4500000
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
-6000
-5000
-4000
-3000
-2000
-1000
0
1000
Distance in feet from top Kmv



Graph 4 - IP Gas vs depth to Uppermost Perforated interval in the Mesaverde Group
IP Gas MCF
0
1000
2000
3000
4000
5000
6000
7000
0
5000
10000
15000
20000
Depth to first perforation


Graph 5 - IP vs Gross interval for Kmv completions
IP GAS MCF
0
1000
2000
3000
4000
5000
6000
7000
0
500
1000
1500
2000
2500
3000
Gross interval



Map 1
Structure Contour
Top of Mesaverde

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey Contract #51846

June 30, 2005

Explanation

Red structure contours on top of Mesaverde.
Contour interval 500 feet elevation

Blue cross is a control well with a Mesaverde top, elevation posted below point in feet.

PP (partial penetration of Mesaverde section well)

Cross section lines

Strike 1,5 = well in cross section line

N

Scale

0 1 2 3 4 5 6

Miles

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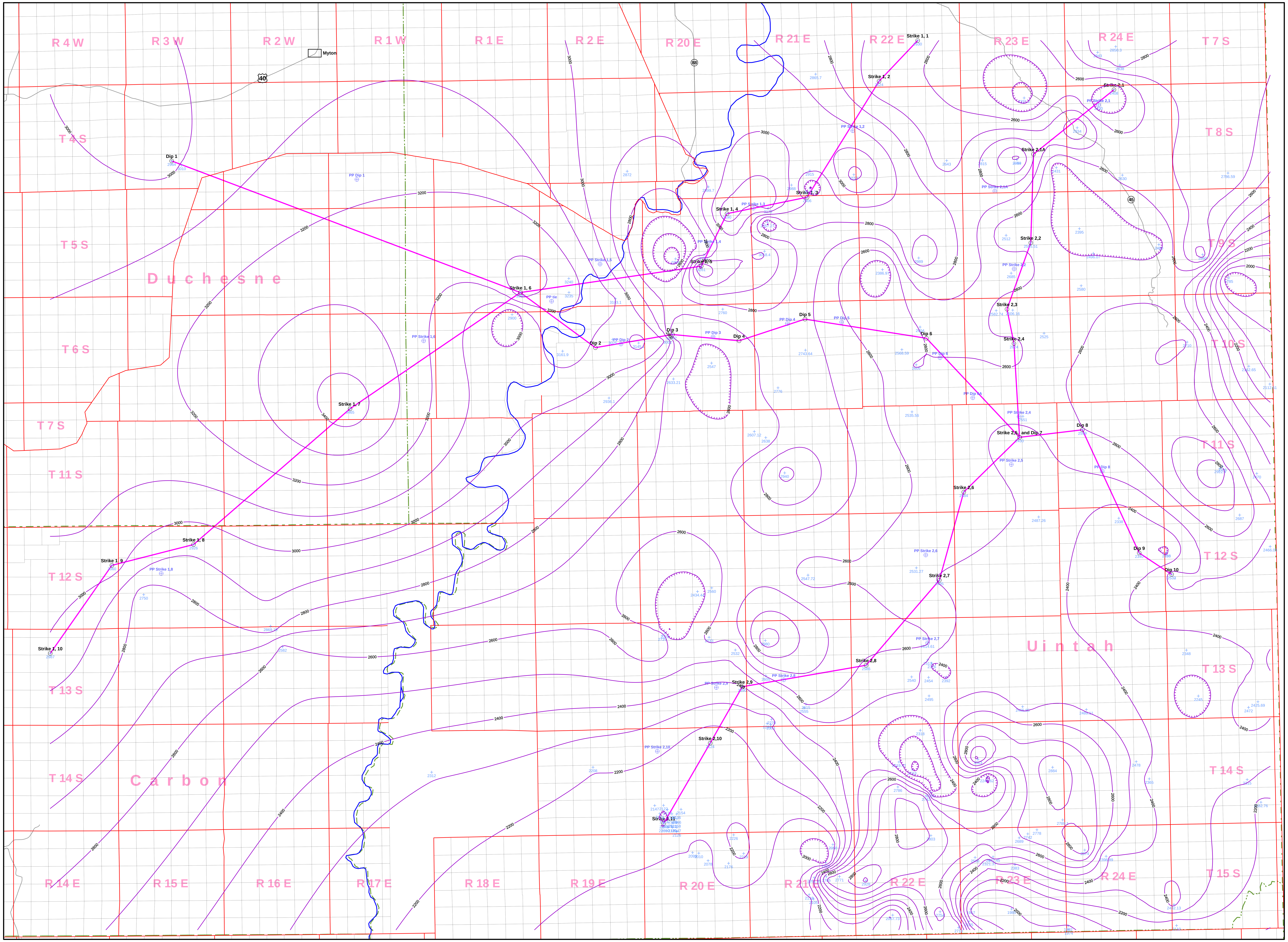
Paul B. Anderson
State of Utah



Map 2
Isopach Map of Mesaverde

Mesaverde Gas of Southeastern Uinta Basin

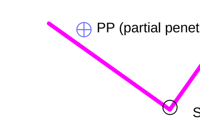
Utah Geological Survey Contract #51846

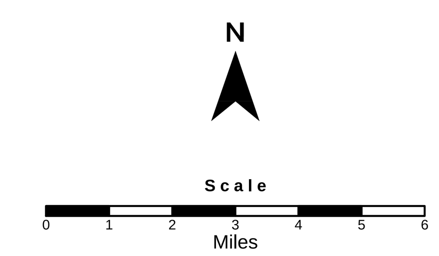
June 30, 2005

Explanation

Purple isopach contours, contour interval 100 feet.

Blue cross is a control well. Mesaverde thickness is posted below point in feet.





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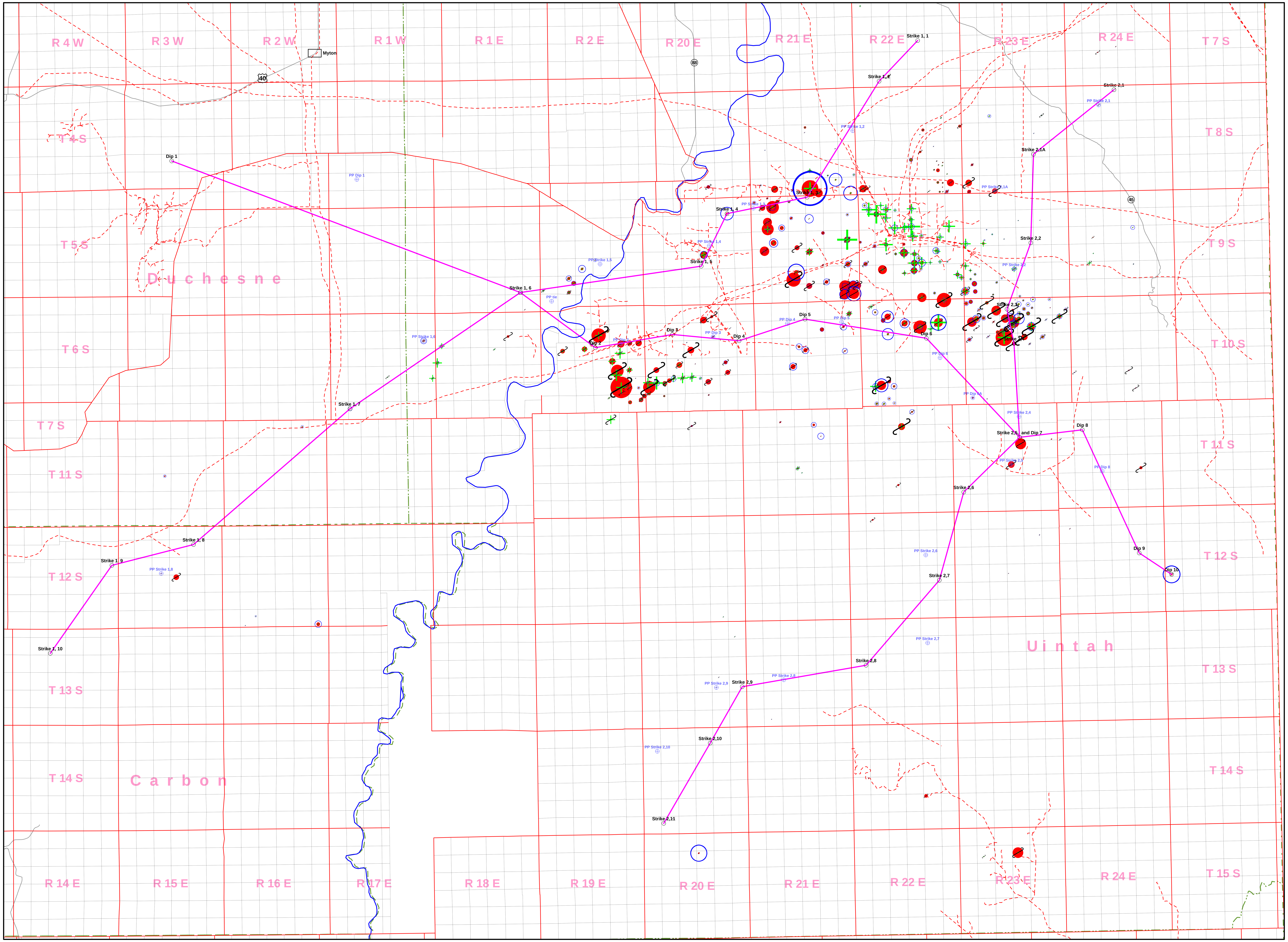

Map 3
Cumulative Production Bubble Map for Mesaverde Completed Gas Wells

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey Contract #51846

June 30, 2005

Explanation

Proportionally scaled symbols
1.0" size as follows:
Gas (red) 2.6 BCF
Oil (green) 20,000 barrels
Water (blue) 100,000 barrels
Years of production (hook) 20 years*

* Based on sum of days produced

Pipeline

PP (partial penetration of Mesaverde section well)

Cross section lines

Strike 1,5 = well in cross section line

N

Scale

0 1 2 3 4 5 6
Miles

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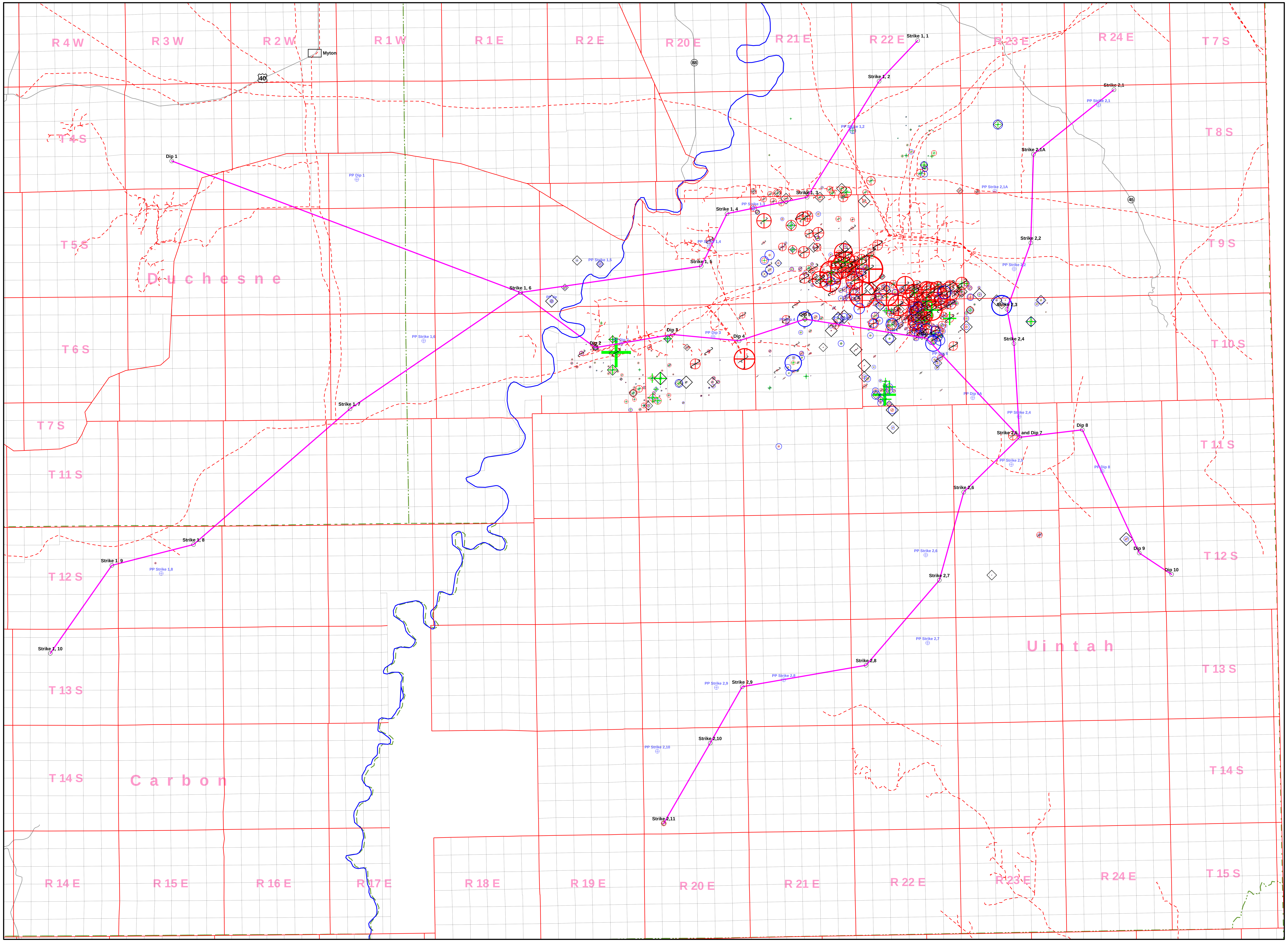

Map 4
Cumulative Production Bubble Map for Wasatch-Mesaverde Completed Gas Wells

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey Contract #51846

June 30, 2005

Explanation

Proportionally scaled symbols
1.0" size as follows:
Gas (red) 2.6 BCF
Oil (green) 20,000 barrels
Water (blue) 100,000 barrels
Years of production (hook) 40 years*

* Based on sum of days produced

Pipeline

PP (partial penetration of Mesaverde section well)

Cross section lines

Strike 1,5 = well in cross section line

N

Scale

0 1 2 3 4 5 6

Miles

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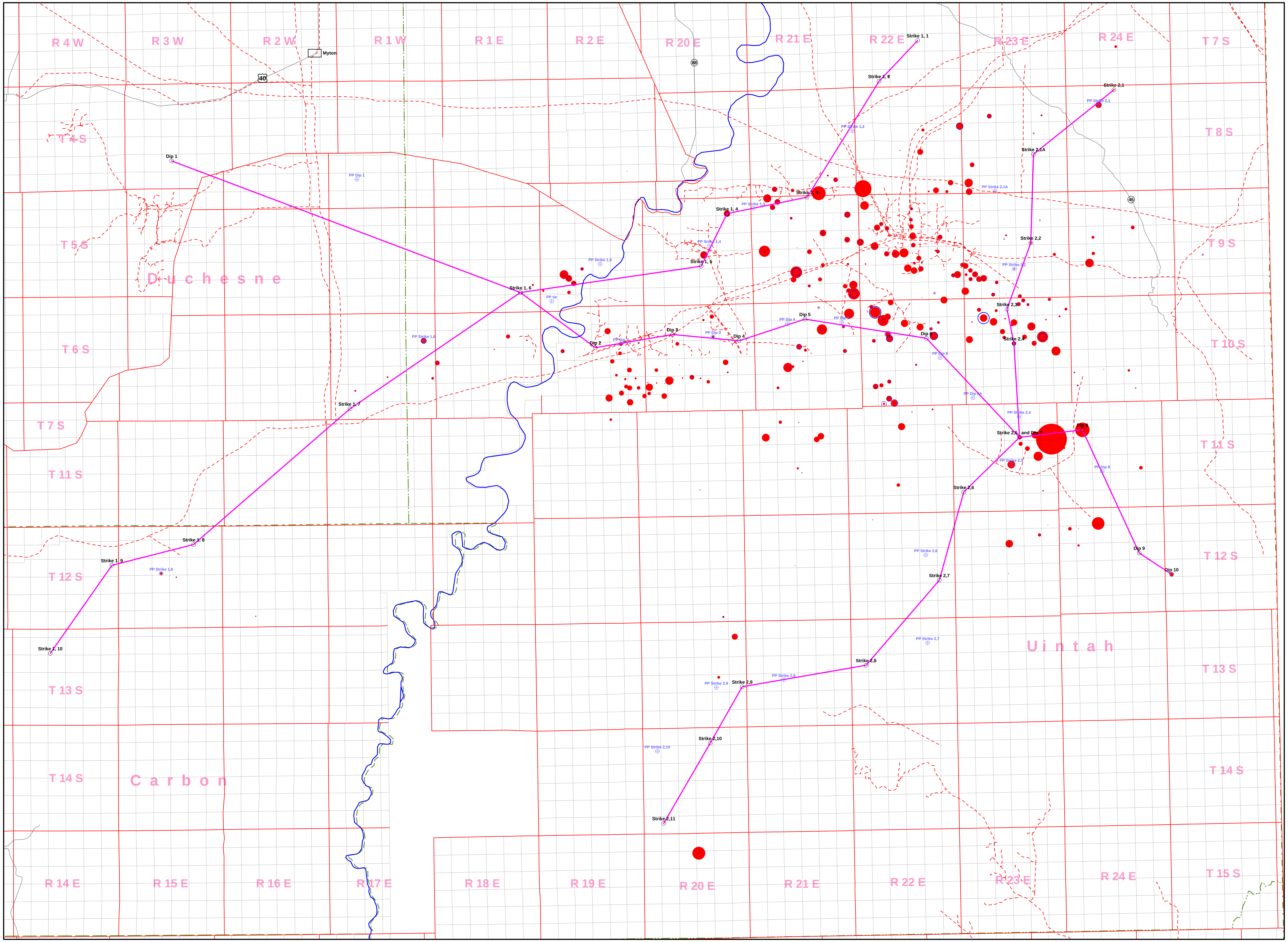

Map 5
Initial Production (IP) Bubble Map for Mesaverde Tests

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey Contract #51846

June 30, 2005

Explanation

Proportionally scaled symbols for test volumes, 1.0" size is as follows:
Gas (red) 6,000 MCF/D
Water (blue) 2,000 bbls/D

Pipeline

PP (partial penetration of Mesaverde section well)

Cross section lines

Strike 1,5 = well in cross section line

N

Scale

0 1 2 3 4 5 6

Miles

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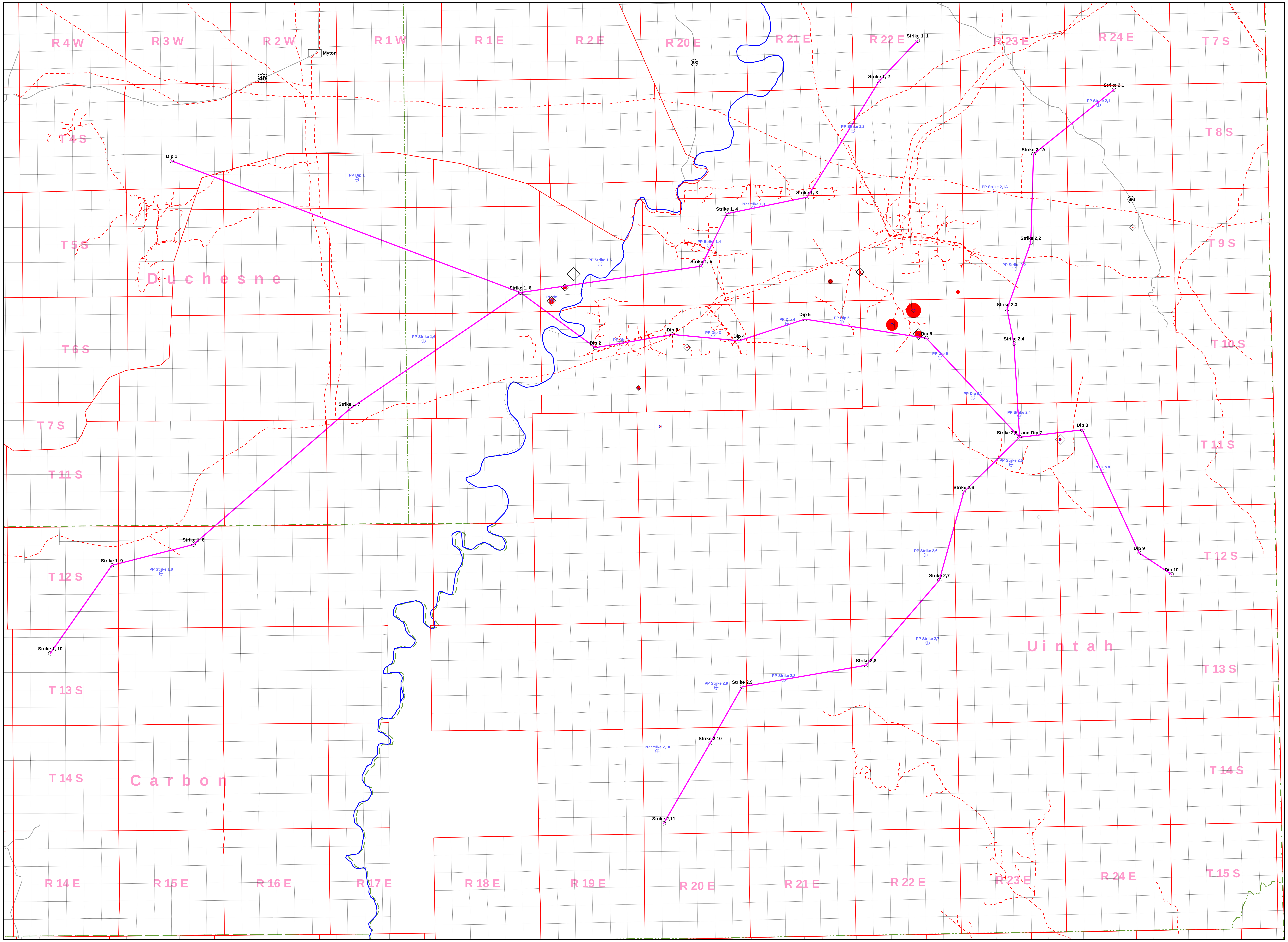

Map 6
Initial Production (IP) Bubble Map for Wasatch-Mesaverde Tests

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey Contract #51846

June 30, 2005

Explanation

Proportionally scaled symbols for test volumes, 1.0" size is as follows:
Gas (red) 6,000 MCF/D
Water (blue) 2,000 bbls/D
Percent Mesaverde perfs (black) 0.5"=100%

Pipeline

PP (partial penetration of Mesaverde section well)

Cross section lines

Strike 1,5 = well in cross section line

N

Scale

0 1 2 3 4 5 6

Miles

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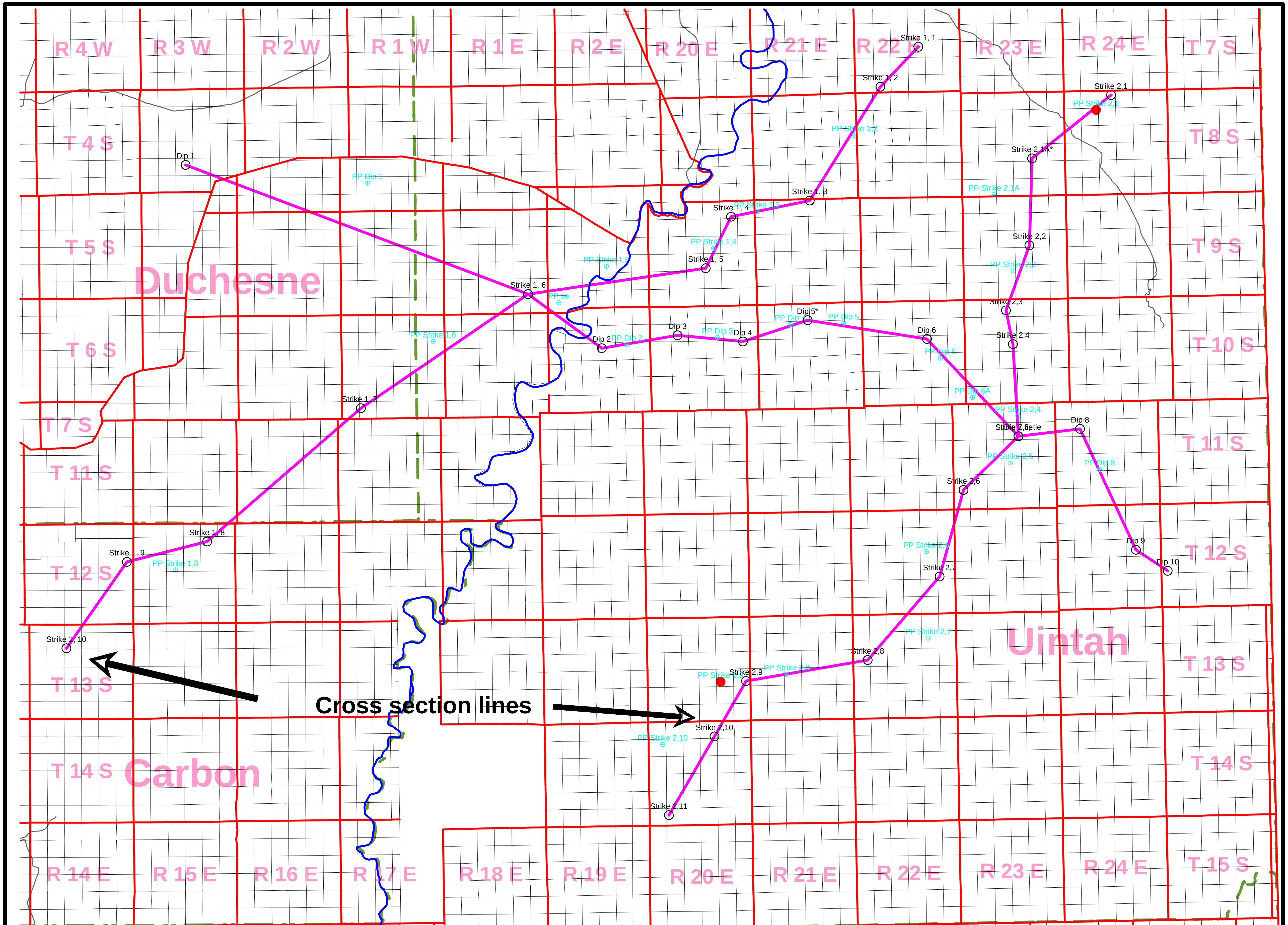

Map 7

Mesaverde Completions with production by Decade
1960

Mesaverde Gas of Southeastern Uinta Basin
Utah Geological Survey
Contract #51846
June 30, 2005

Well completed with production in decade

N

0 1 2 3 4 5 6
Miles

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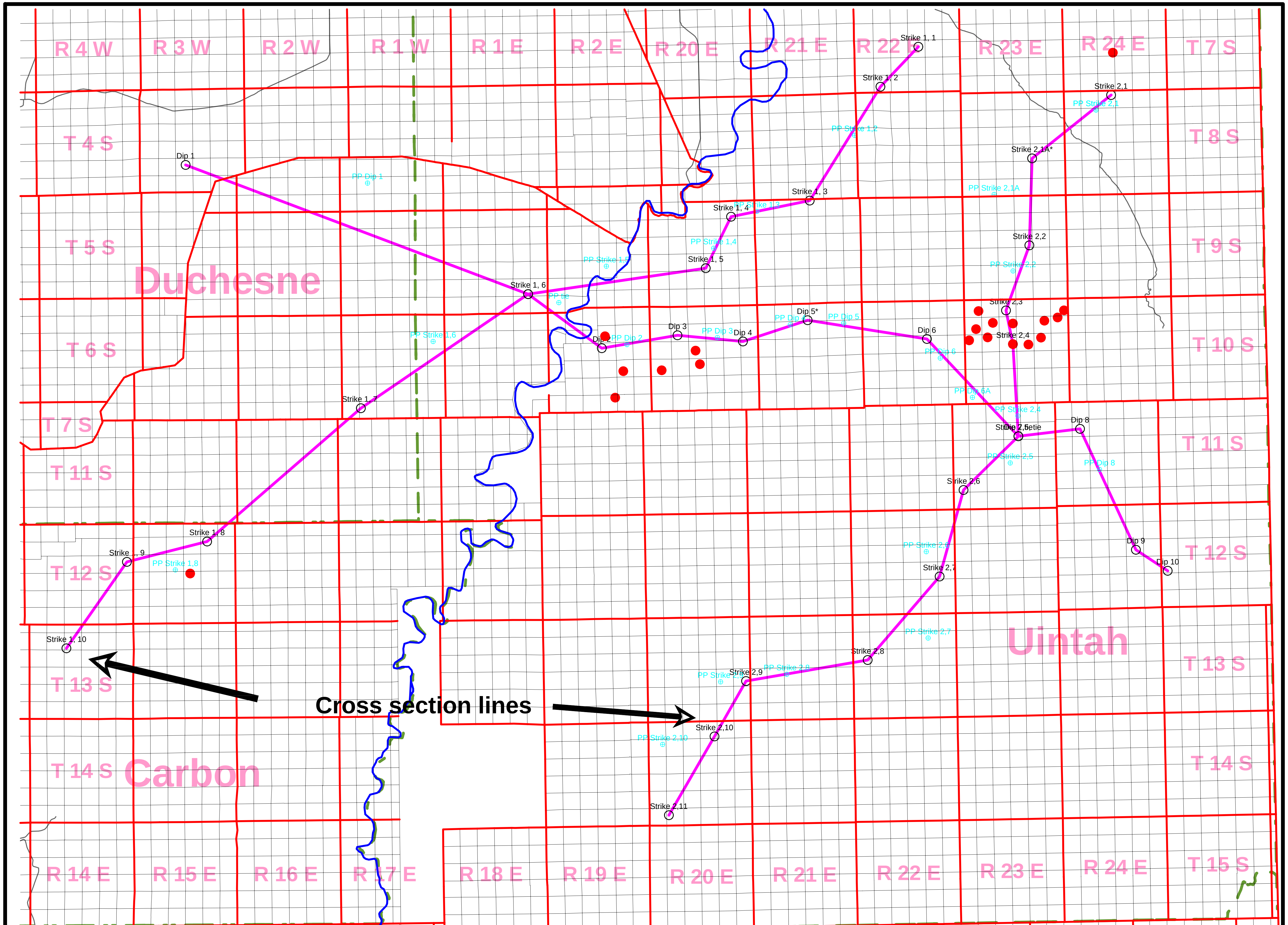

Map 8

Mesaverde Completions with production by Decade
1970

Mesaverde Gas of Southeastern Uinta Basin
Utah Geological Survey
Contract #51846
June 30, 2005

Well completed with production in decade

N

0 1 2 3 4 5 6
Miles

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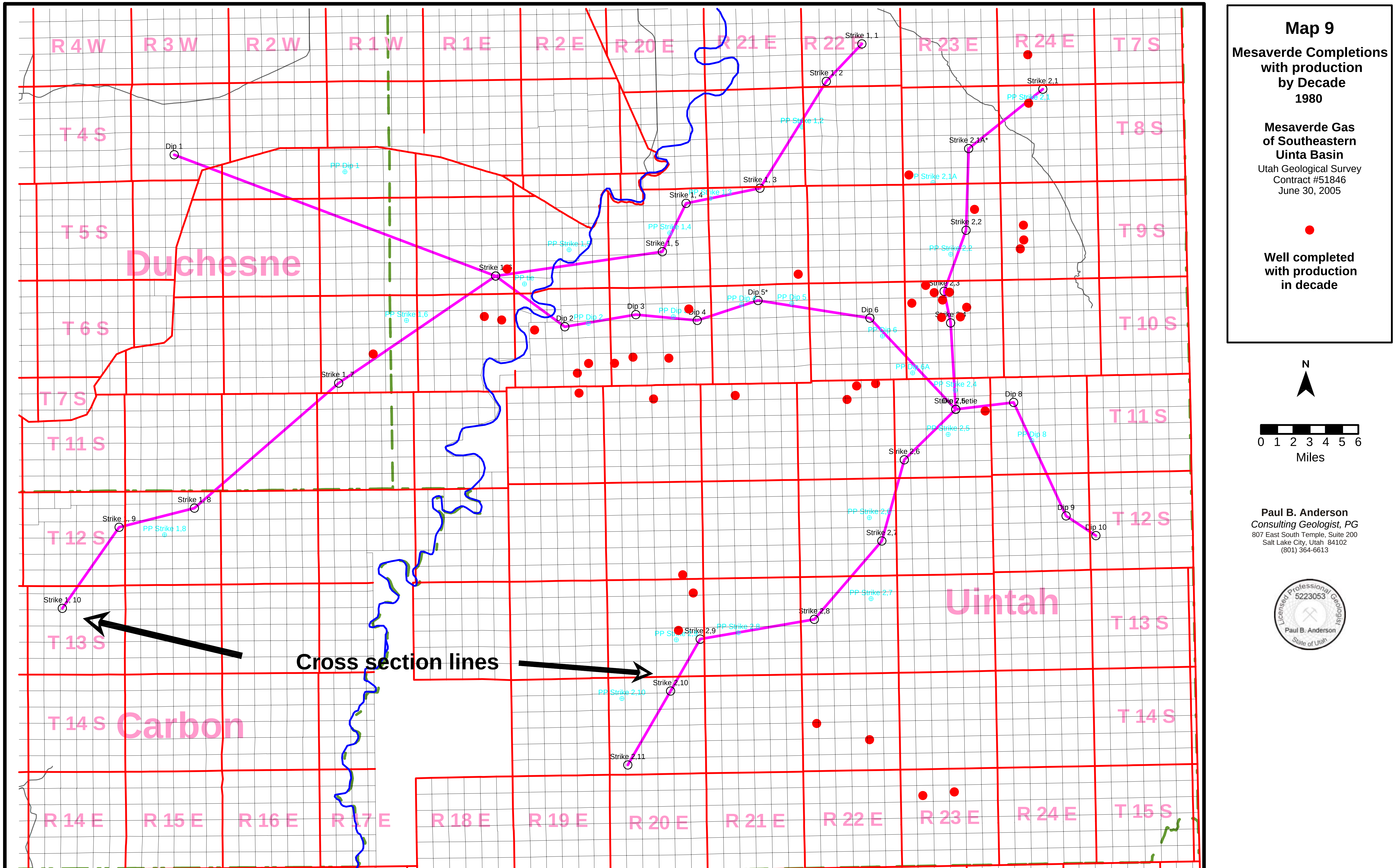

Map 9
Mesaverde Completions with production by Decade
1980
Mesaverde Gas of Southeastern Uinta Basin
Utah Geological Survey
Contract #51846
June 30, 2005
Well completed with production in decade
N
0 1 2 3 4 5 6
Miles
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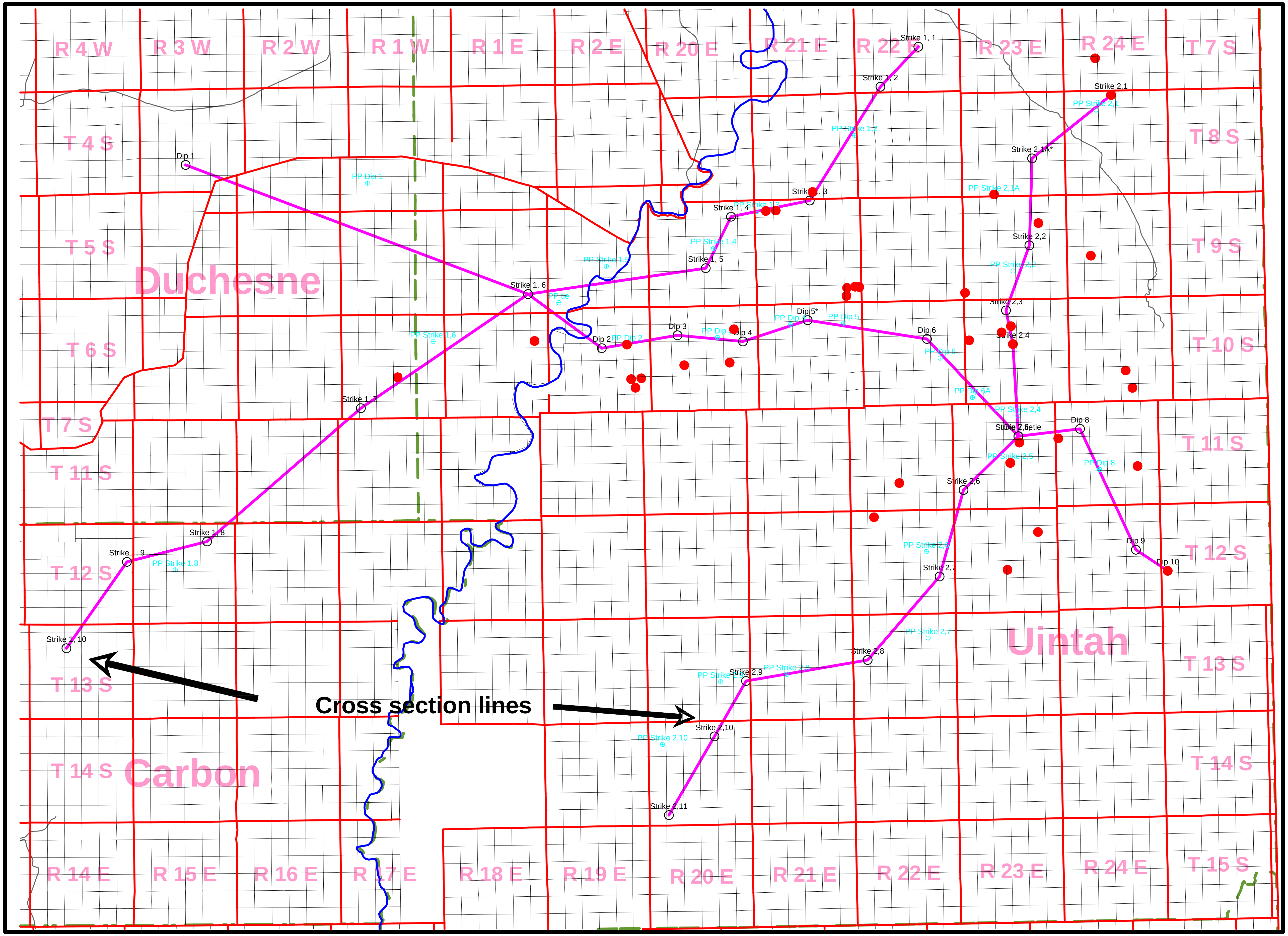
Duchesne
Uintah
Carbon
Cross section lines
R 4 W
R 3 W
R 2 W
R 1 W
R 1 E
R 2 E
R 20 E
R 21 E
R 22 E
R 23 E
R 24 E
R 14 E
R 15 E
R 16 E
R 17 E
R 18 E
R 19 E
T 4 S
T 5 S
T 6 S
T 7 S
T 8 S
T 9 S
T 10 S
T 11 S
T 12 S
T 13 S
T 14 S
T 15 S
Dip 1
Dip 2
Dip 3
Dip 4
Dip 5*
Dip 6
Dip 8
Dip 9
Dip 10
Strike 1, 1
Strike 1, 2
Strike 1, 3
Strike 1, 4
Strike 1, 5
Strike 1, 7
Strike 1, 8
Strike 1, 9
Strike 1, 10
Strike 2,1
Strike 2,1A*
Strike 2,2
Strike 2,3
Strike 2,6
Strike 2,7
Strike 2,8
Strike 2,9
Strike 2,10
Strike 2,11



Map 10

Mesaverde Completions with production by Decade
1990

Mesaverde Gas of Southeastern Uinta Basin
Utah Geological Survey
Contract #51846
June 30, 2005

Well completed with production in decade

N

0 1 2 3 4 5 6
Miles

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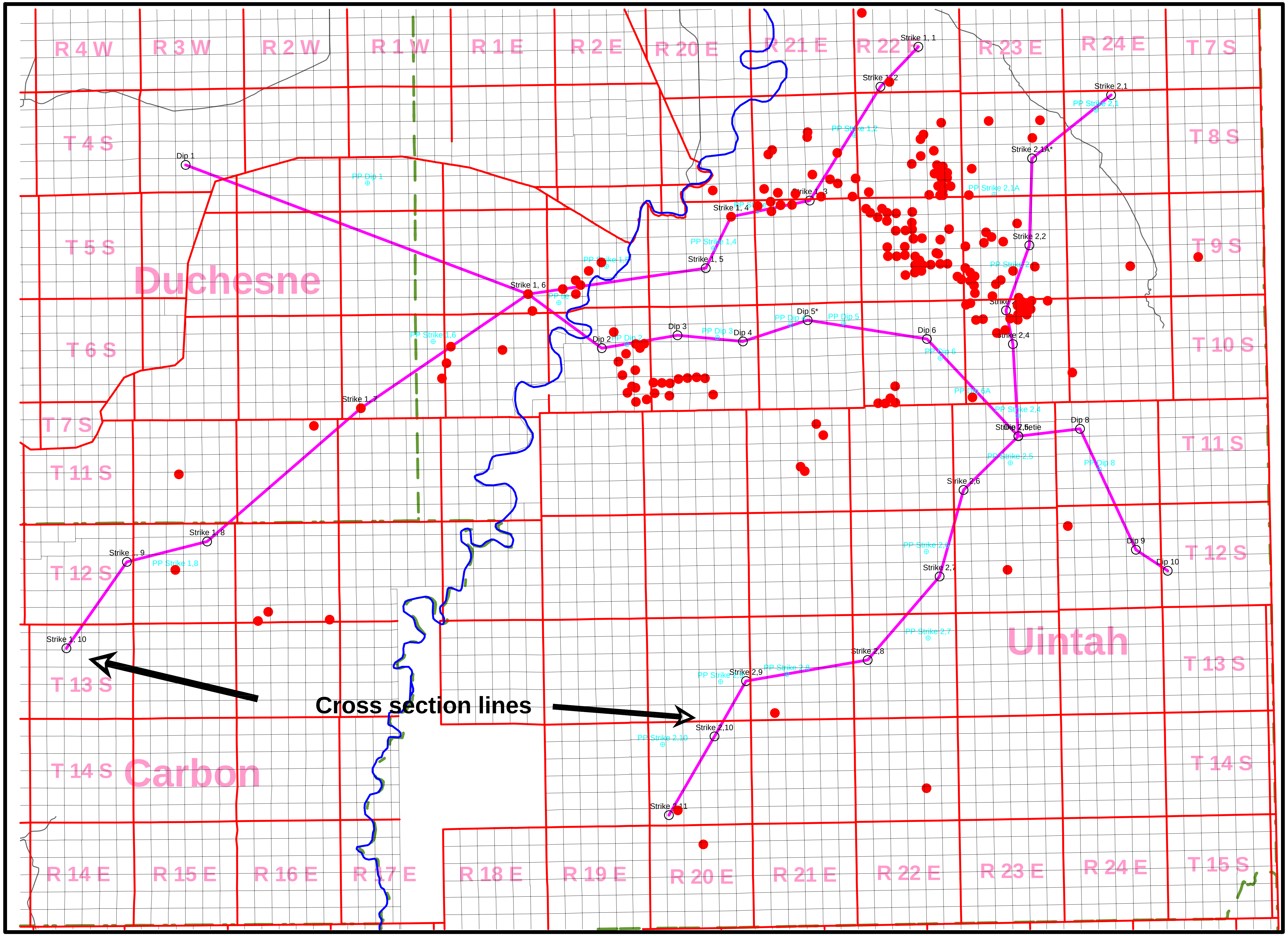

Map 11

Mesaverde Completions with production by Decade 2000-2004

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey
Contract #51846
June 30, 2005

● **Well completed with production in decade**

N

0 1 2 3 4 5 6
Miles

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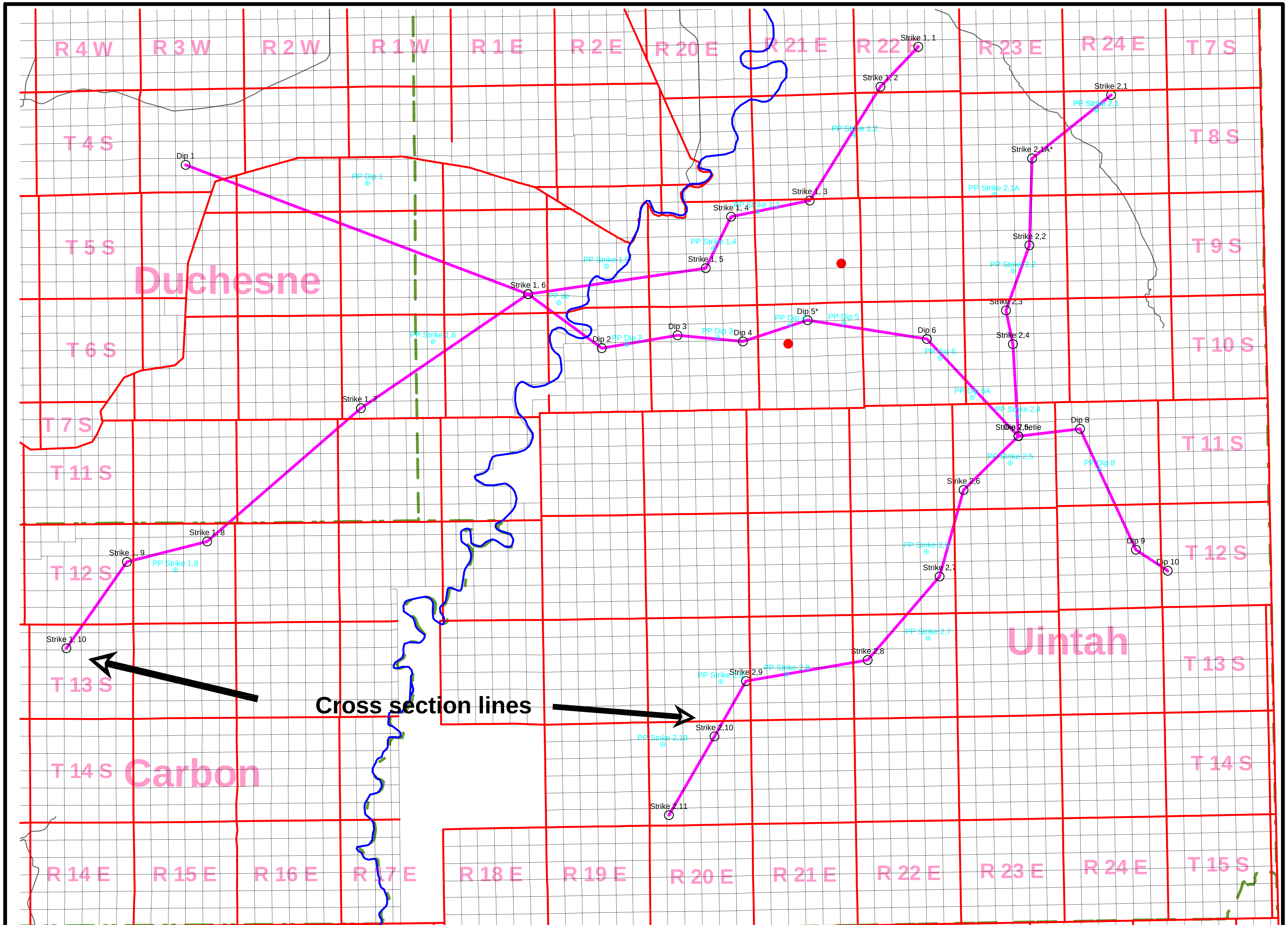

Map 12
Wasatch-Mesaverde Completions with production by decade
1960

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey
Contract #51846
June 30, 2005

● **Well completed with production in decade**

N

0 1 2 3 4 5 6
Miles

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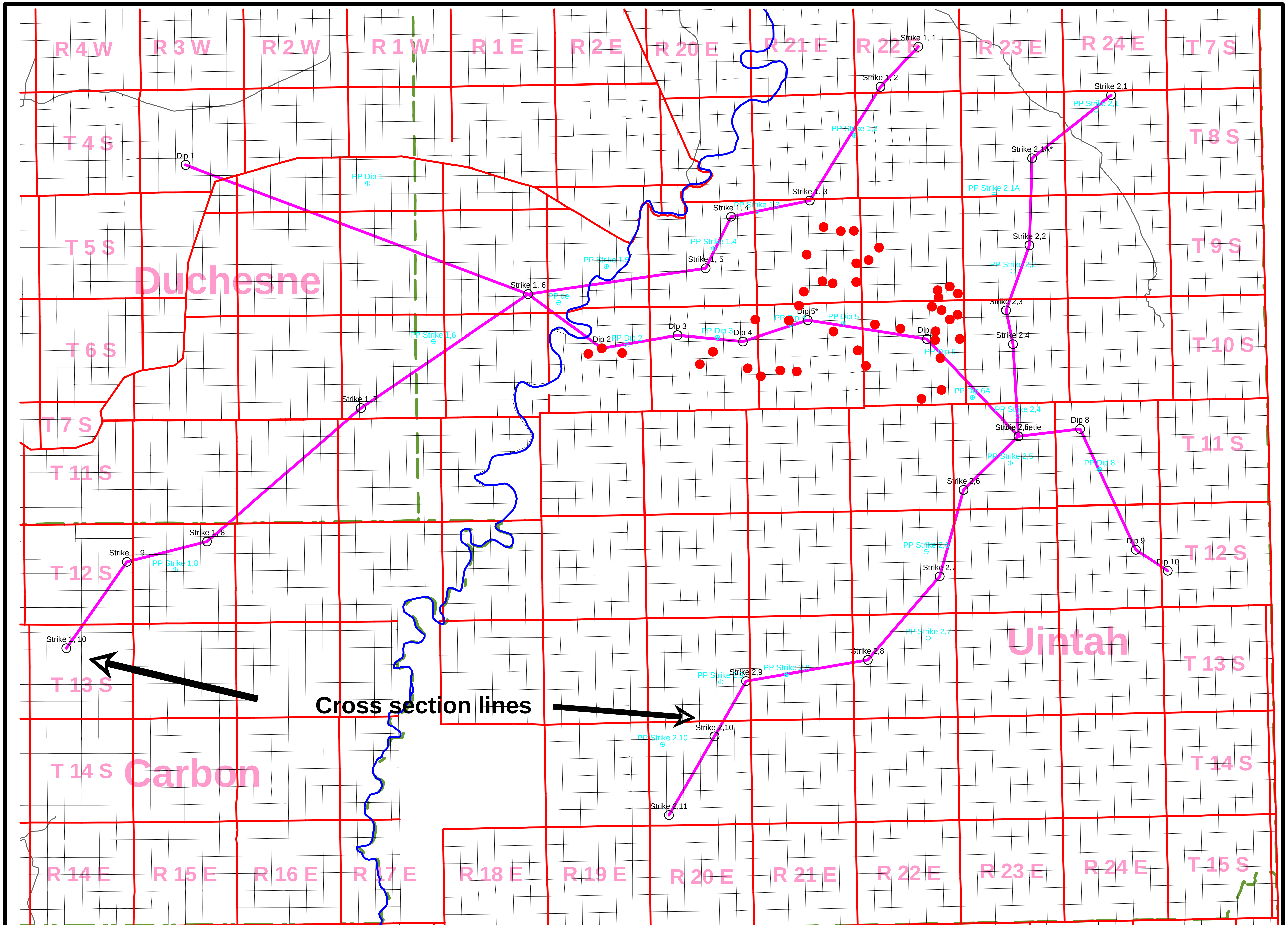

Map 13

Wasatch-Mesaverde Completions with production by decade

1970

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey
Contract #51846
June 30, 2005

● **Well completed with production in decade**

N

0 1 2 3 4 5 6
Miles

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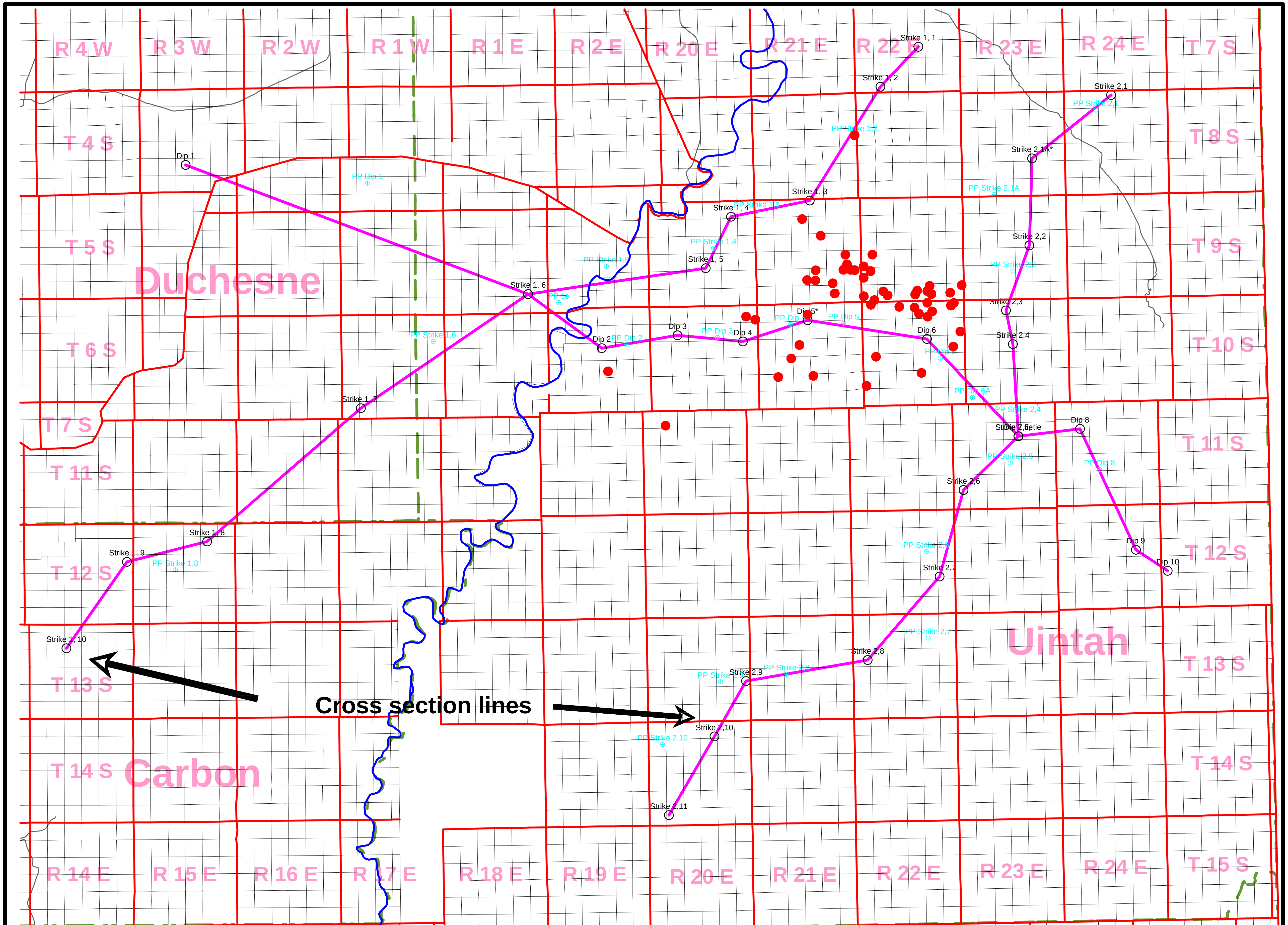

Map 14
Wasatch-Mesaverde Completions with production by decade

1980

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey
Contract #51846
June 30, 2005

● **Well completed with production in decade**

N

0 1 2 3 4 5 6
Miles

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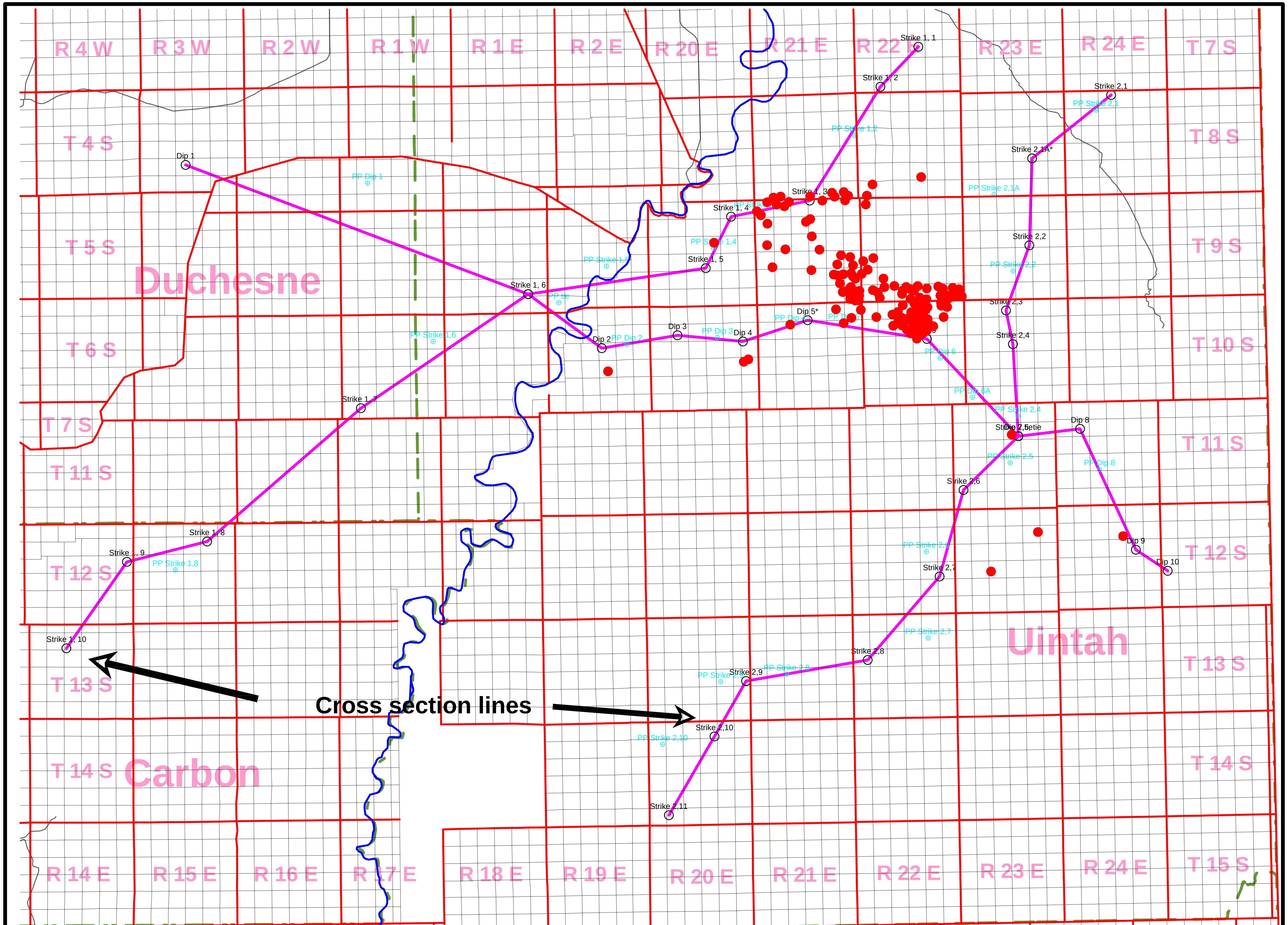

Map 15

Wasatch-Mesaverde Completions with production by decade

1990

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey
Contract #51846
June 30, 2005

Well completed with production in decade

N

0 1 2 3 4 5 6
Miles

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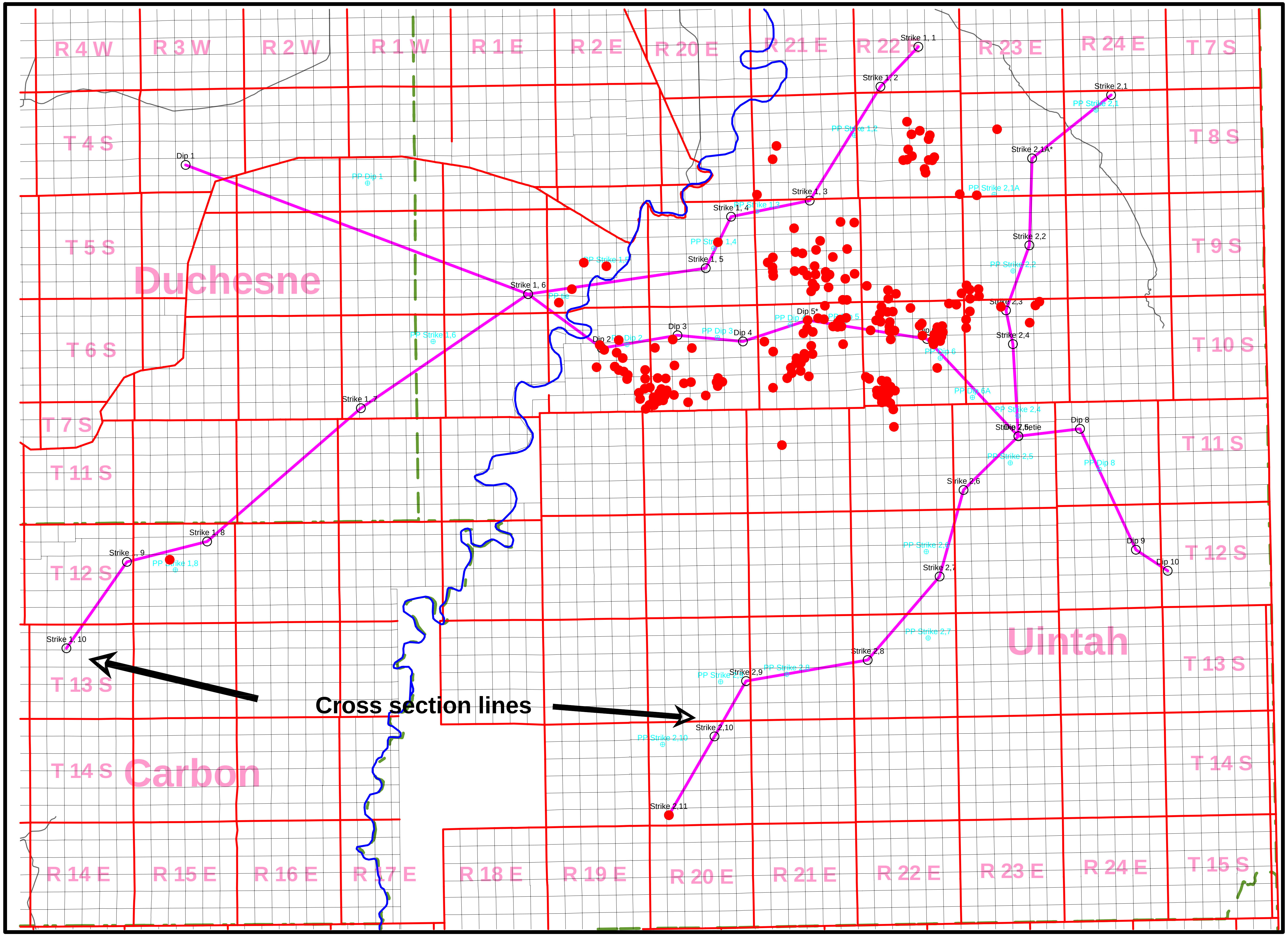

Map 16
Wasatch-Mesaverde Completions with production by decade

2000-2004

Mesaverde Gas of Southeastern Uinta Basin

Utah Geological Survey
Contract #51846
June 30, 2005

● **Well completed with production in decade**

N

0 1 2 3 4 5 6
Miles

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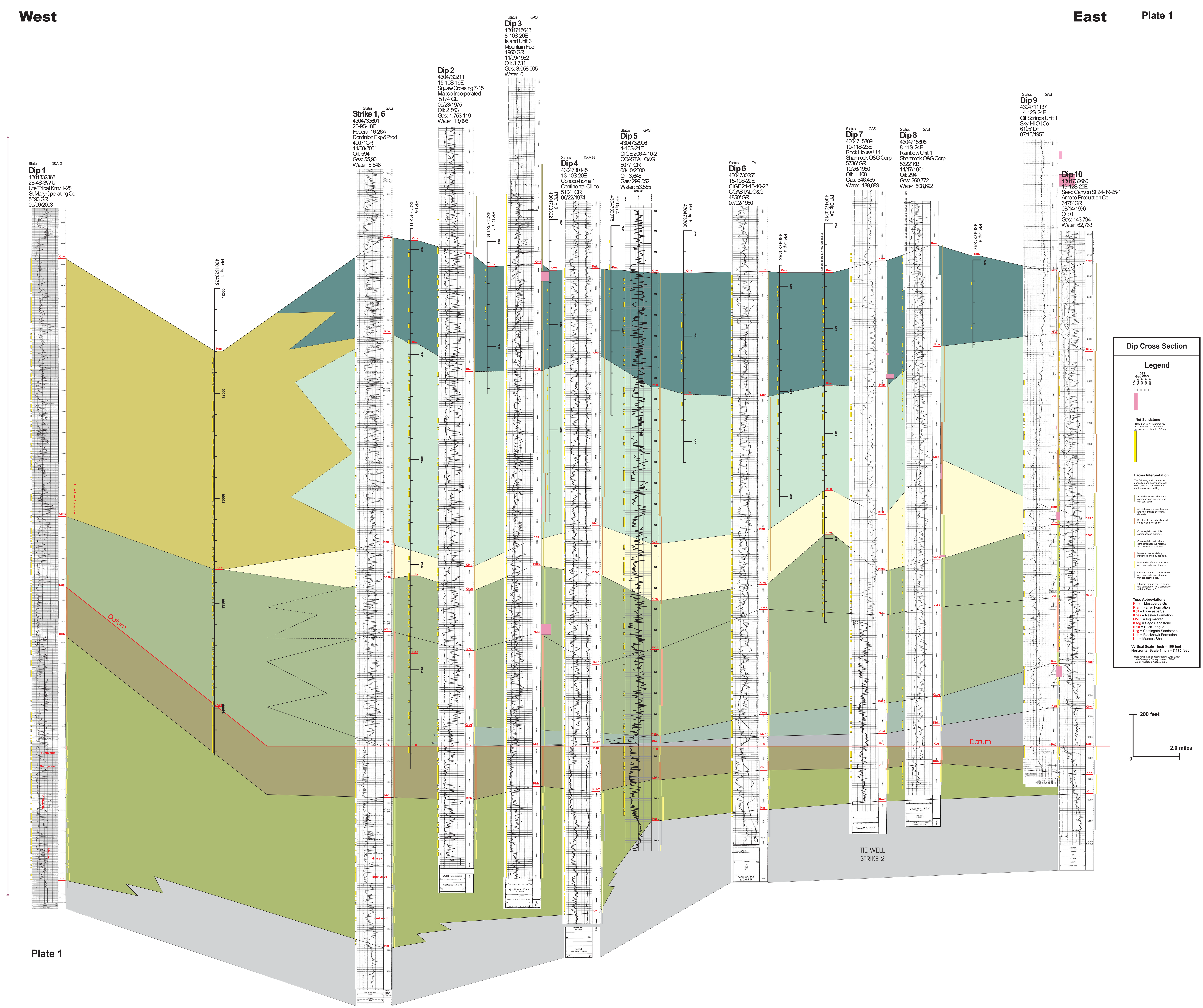

West
East
Plate 1
Dip 1
4301332368
28-4S-3W U
Ute Tribal Kmv 1-28
St Mary Operating Co
5593 GR
09/06/2003
Strike 1, 6
4304733601
26-9S-18E
Federal 16-26A
Dominion Expl&Prod
4907' GR
11/08/2001
Oil: 594
Gas: 55,931
Water: 5,848
Dip 2
4304730211
15-10S-19E
Squaw Crossing 7-15
Mapco Incorporated
5174 GL
09/23/1975
Oil: 2,863
Gas: 1,753,119
Water: 13,096
Dip 3
4304715643
8-10S-20E
Island Unit 3
Mountain Fuel
4960 GR
11/09/1962
Oil: 3,734
Gas: 3,058,005
Water: 0
Dip 4
4304730145
13-10S-20E
Conoco-horne 1
Continental Oil co
5104 GR
06/22/1974
Dip 5
4304732996
4-10S-21E
CIGE 206-4-10-2
COASTAL O&G
5077' GR
08/10/2000
Oil: 3,646
Gas: 299,552
Water: 53,555
Dip 6
4304730255
15-10S-22E
CIGE 21-15-10-22
COASTAL O&G
4850' GR
07/02/1980
Dip 7
4304715809
10-11S-23E
Rock House U 1
Shamrock O&G Corp
5736' GR
10/26/1960
Oil: 1,408
Gas: 546,455
Water: 189,889
Dip 8
4304715805
8-11S-24E
Rainbow Unit 1
Shamrock O&G Corp
5322' KB
11/17/1961
Oil: 294
Gas: 260,772
Water: 508,692
Dip 9
4304711137
14-12S-24E
Oil Springs Unit 1
Sky-Hi Oil Co
6195' DF
07/15/1956
Dip 10
4304732660
19-12S-25E
Seep Canyon St 24-19-25-1
Amoco Production Co
6478' GR
08/14/1996
Oil: 0
Gas: 143,794
Water: 62,763
PP Dip 1
4301333435
PP Ile
4304734201
PP Dip 2
4304733194
PP Dip 3
4304733362
PP Dip 4
4304732975
PP Dip 5
4304733001
PP Dip 6
4304730463
PP Dip 6A
4304733312
PP Dip 8
4304731897
Datum
TIE WELL
STRIKE 2
200 feet
2.0 miles
0
Dip Cross Section
Legend
DST
Gas (MCF)
0.00
50.00
100.00
150.00
200.00
Net Sandstone
Based on 60 API gamma-ray log unless noted otherwise or interpreted from the SP log.
Facies Interpretation
The following environments of deposition and descriptions with color code are posted on the right side of each full log.
Alluvial-plain with abundant carbonaceous material and thin coal beds.
Alluvial-plain - channel sands and fine-grained overbank deposits.
Braided stream - cheifly sand-stone with minor shale.
Coastal-plain - with little carbonaceous material.
Coastal-plain - with abun-dant carbonaceous material and occasional coal beds.
Marginal marine - tidally influenced and bay deposits.
Marine shoreface - sandstone and minor siltstone deposits.
Offshore marine - chiefly shale and minor siltstone with rare thin sandstone beds.
Offshore marine bar - siltstone and sandstone, likely correlative with the Mancos B.
Tops Abbreviations
Kmv = Mesaverde Gp
Kfar = Farrer Formation
Kblt = Bluecastle Ss.
Knes = Neslen Formation
MVL5 = log marker
Kseg = Sego Sandstone
Kbkt = Buck Tongue
Kcg = Castlegate Sandstone
Kbh = Blackhawk Formation
Km = Mancos Shale
Vertical Scale 1inch = 100 feet
Horizontal Scale 1inch = 7,175 feet
Mesaverde Gas of southeastern Uinta Basin
Utah Geological Survey contract: 51846
Paul B. Anderson, August, 2005
Plate 1


West
East
Plate 1
Dip 1
4301332368
28-4S-3W U
Ute Tribal Kmv 1-28
St Mary Operating Co
5593 GR
09/06/2003
Strike 1, 6
4304733601
26-9S-18E
Federal 16-26A
Dominion Expl&Prod
4907' GR
11/08/2001
Oil: 594
Gas: 55,931
Water: 5,848
Dip 2
4304730211
15-10S-19E
Squaw Crossing 7-15
Mapco Incorporated
5174 GL
09/23/1975
Oil: 2,863
Gas: 1,753,119
Water: 13,096
Dip 3
4304715643
8-10S-20E
Island Unit 3
Mountain Fuel
4960 GR
11/09/1962
Oil: 3,734
Gas: 3,058,005
Water: 0
Dip 4
4304730145
13-10S-20E
Conoco-home 1
Continental Oil co
5104 GR
06/22/1974
Dip 5
4304732996
4-10S-21E
CIGE 206-4-10-2
COASTAL O&G
5077' GR
08/10/2000
Oil: 3,646
Gas: 299,552
Water: 53,555
Dip 6
4304730255
15-10S-22E
CIGE 21-15-10-22
COASTAL O&G
4850' GR
07/02/1980
Dip 7
4304715809
10-11S-23E
Rock House U 1
Shamrock O&G Corp
5736' GR
10/26/1960
Oil: 1,408
Gas: 546,455
Water: 189,889
Dip 8
4304715805
8-11S-24E
Rainbow Unit 1
Shamrock O&G Corp
5322' KB
11/17/1961
Oil: 294
Gas: 260,772
Water: 508,692
Dip 9
4304711137
14-12S-24E
Oil Springs Unit 1
Sky-Hi Oil Co
6195' DF
07/15/1956
Dip 10
4304732660
19-12S-25E
Seep Canyon St 24-19-25-1
Amoco Production Co
6478' GR
08/14/1996
Oil: 0
Gas: 143,794
Water: 62,763
PP Dip 1 4301330435
PP tie 4304734201
PP Dip 2 4304733194
PP Dip 3 4304733362
PP Dip 4 4304732975
PP Dip 5 4304733001
PP Dip 6 4304730463
PP Dip 6A 4304733312
PP Dip 8 4304731897
Datum
TIE WELL STRIKE 2
Dip Cross Section
Legend
DST Gas (MCF)
Net Sandstone
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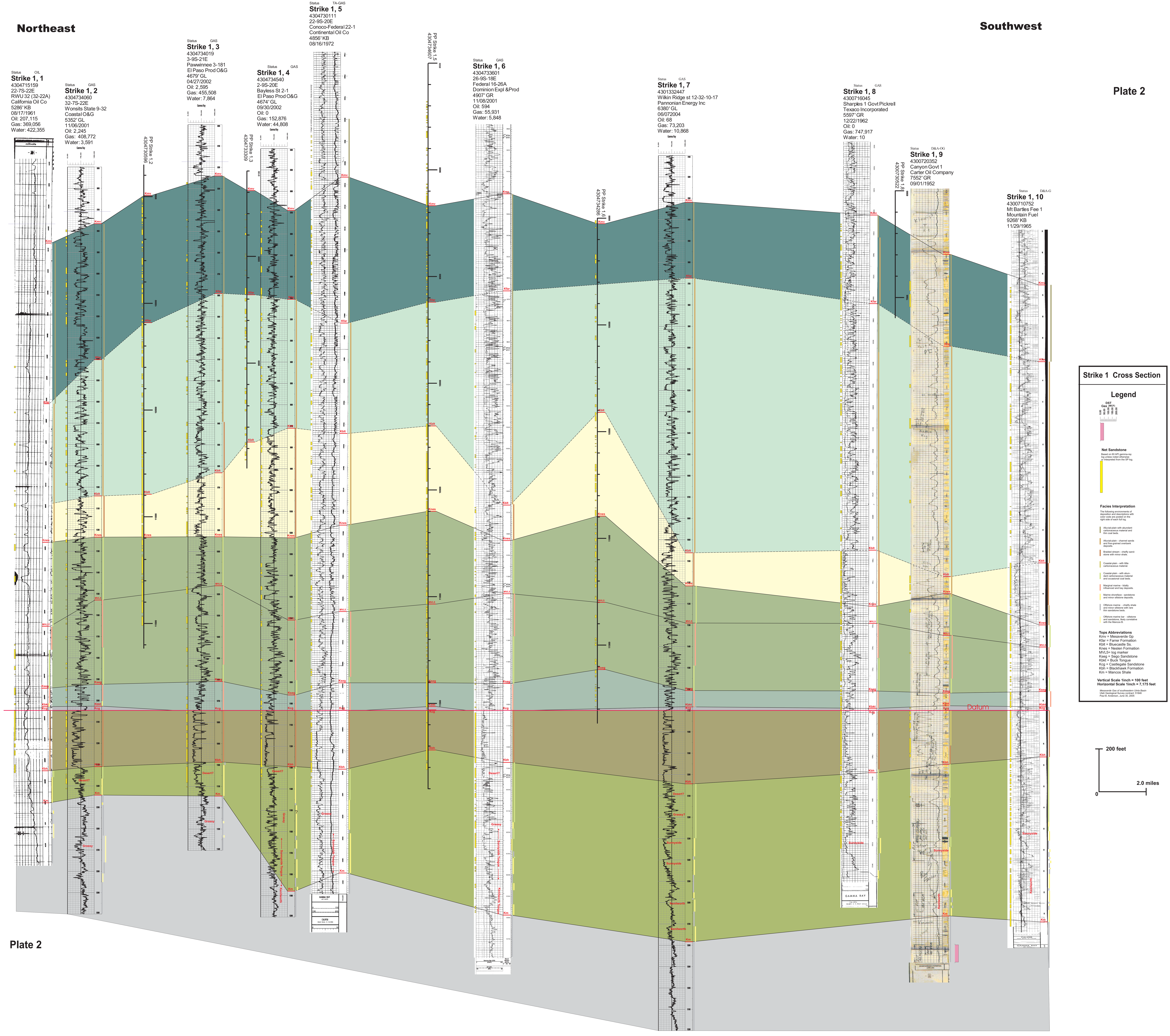
Vertical Scale 1inch = 100 feet
Horizontal Scale 1inch = 7,175 feet
Mesaverde Gas of southeastern Uinta Basin
Utah Geological Survey contract: 51846
June 30, 2005
Paul B. Anderson
Consulting Geologist, PG
807 East South Temple #200
Salt Lake City, Utah 84102
801-364-6613
Licensed Professional Geologist 5223053 Paul B. Anderson State of Utah
200 feet
2.0 miles
0

Plate 1


Northeast
Southwest
Plate 2
Status OIL
Strike 1, 1
4304715159
22-7S-22E
RWU 32 (32-22A)
California Oil Co
5286' KB
08/17/1961
Oil: 207,115
Gas: 369,056
Water: 422,355
Status GAS
Strike 1, 2
4304734060
32-7S-22E
Wonsits State 9-32
Coastal O&G
5352' GL
11/06/2001
Oil: 2,245
Gas: 408,772
Water: 3,591
PP Strike 1, 2
4304730686
Status GAS
Strike 1, 3
4304734019
3-9S-21E
Pawwinnee 3-181
El Paso Prod O&G
4679' GL
04/27/2002
Oil: 2,595
Gas: 455,508
Water: 7,864
PP Strike 1, 3
4304733309
Status GAS
Strike 1, 4
4304734540
2-9S-20E
Bayless St 2-1
El Paso Prod O&G
4674' GL
09/30/2002
Oil: 0
Gas: 152,876
Water: 44,808
Status TA-GAS
Strike 1, 5
4304730111
22-9S-20E
Conoco-Federal 22-1
Continental Oil Co
4856' KB
08/16/1972
PP Strike 1, 5
4304734607
Status GAS
Strike 1, 6
4304733601
26-9S-18E
Federal 16-26A
Dominion Expl & Prod
4907' GR
11/08/2001
Oil: 594
Gas: 55,931
Water: 5,848
PP Strike 1, 6
4304734286
Status GAS
Strike 1, 7
4301332447
Wilkin Ridge st 12-32-10-17
Pannonian Energy Inc
6380' GL
06/072004
Oil: 68
Gas: 73,203
Water: 10,868
Status GAS
Strike 1, 8
4300716045
Sharples 1 Govt Pickrell
Texaco Incorporated
5597' GR
12/22/1962
Oil: 0
Gas: 747,917
Water: 10
PP Strike 1, 8
4300730522
Status D&A-OG
Strike 1, 9
4300720352
Canyon Govt 1
Carter Oil Company
7552' GR
09/01/1952
Status D&A-G
Strike 1, 10
4300710752
Mt Bartles Fee 1
Mountain Fuel
9268' KB
11/29/1965
Kmv
Kfar
Kblt
Knes
MVL5
Kseg
Kbkt
Kcg
Kbh
Km
Desert?
Grassy
Sunnyside
Kenilworth
Datum
Strike 1 Cross Section
Legend
DST
Gas (MCF)
0.00
50.00
100.00
150.00
200.00
Net Sandstone
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Utah Geological Survey contract: 51846
Paul B. Anderson, June 30, 2005
200 feet
2.0 miles
0

Northeast
Southwest
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Strike 1, 7
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6380' GL
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Carter Oil Company
7552' GR
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Status D&A-G
Strike 1, 10
4300710752
Mt Bartles Fee 1
Mountain Fuel
9268' KB
11/29/1965
Kmv
Kfar
Kblt
Knes
MVL5
Kseg
Kbkt
Kcg
Kbh
Km
Desert?
Grassy
Sunnyside
Kenilworth
Datum
GAMMA RAY
CALIPER
Strike 1 Cross Section
Legend
DST Gas (MCF)
0.00 50.00 100.00 150.00 200.00
Net Sandstone
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200 feet
2.0 miles
0

Plate 2

Northeast

Southwest

Plate 3

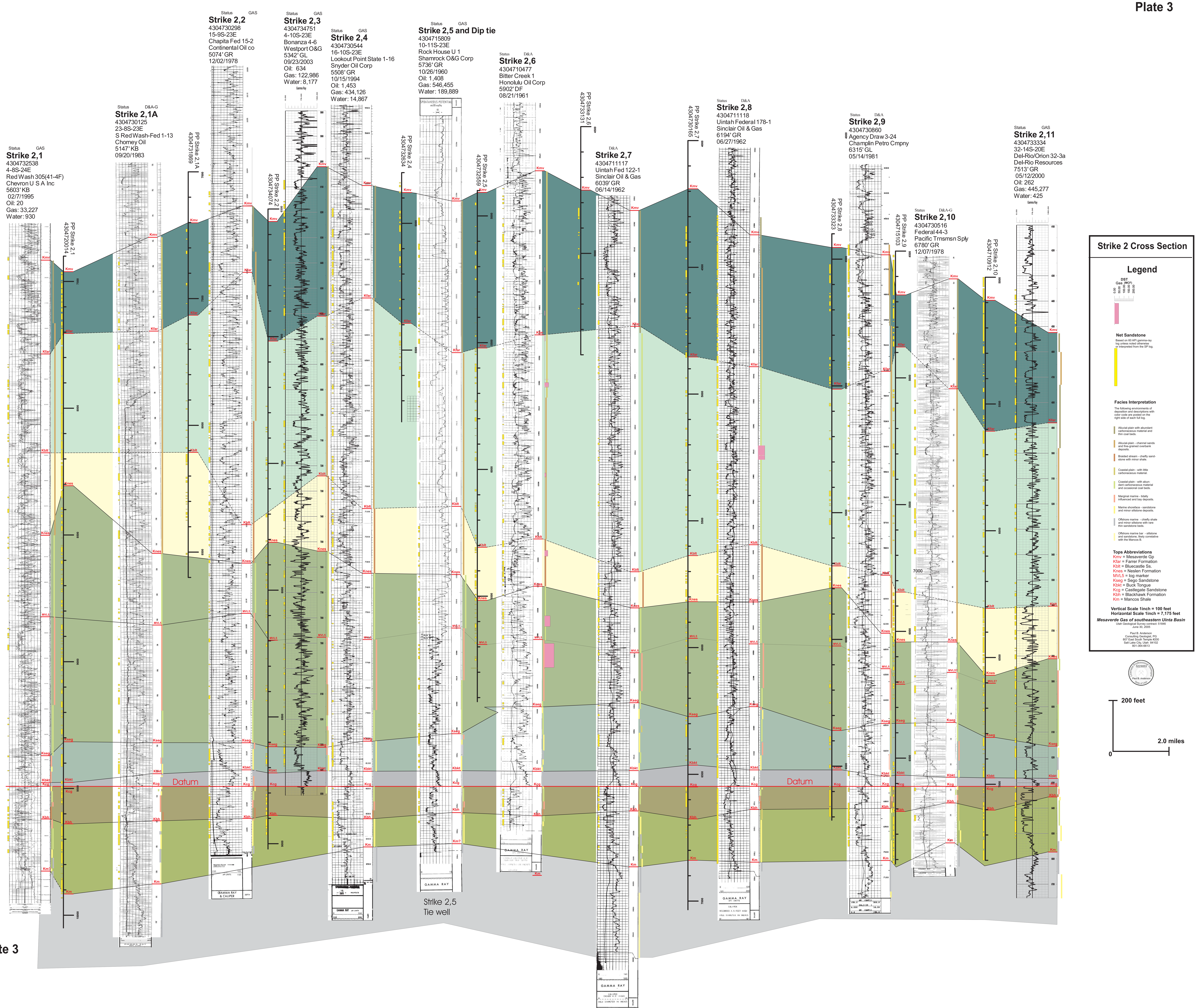

Plate 3

Northeast **Southwest**

Plate 3

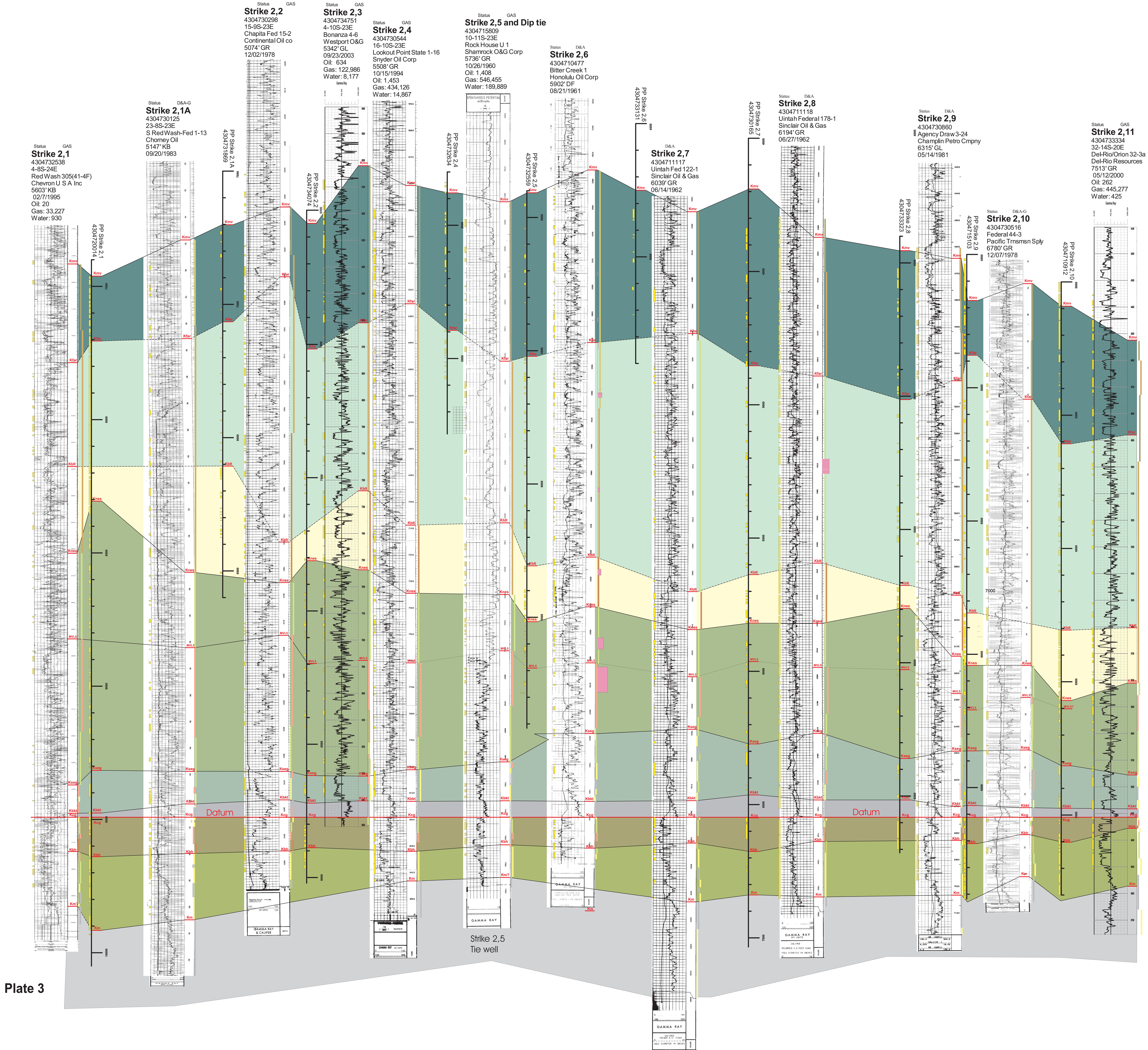

Plate 3

Strike 2 Cross Section

Legend

DST Gas (MCF)
0.00 50.00 100.00 150.00 200.00

Net Sandstone
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200 feet
0
2.0 miles