

Atlantic Rim Coalbed Methane Play: The Newest Successful CBM Play in the Rockies

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Introduction

The Atlantic Rim Coalbed Methane Play is rapidly becoming one of the most significant new CBM discoveries in the Rockies. The play is on the shallow eastern margin of the Washakie Basin, in Carbon County, Wyoming. The play area is 55 miles long (north-south) by five miles wide (east-west), targeting prospective coals in the Almond and Allen Ridge Formations of the Upper Cretaceous Mesaverde Group.

Twenty-nine wells are currently producing gas and water from three different pods within the play. Double Eagle Petroleum has recently increased its production with the installation of a new compressor, two new generators, a dehydration unit and an additional disposal well at the Cow Creek Unit in T16N, R91-92W. Nine wells are now producing 4453 Mcfd and 14,240 Bwpd (**Fig. 1**). The average production per well is 495 Mcfd and 1582 Bwpd from depths ranging from 1100 to 1800 ft. Two wells have been tested at rates close to 1 MMcfd each (**Fig. 2**). Continuity of the coal zones is good across the field (**Fig. 3**). All wells produce gas immediately after a small fracture stimulation of about 30,000 pounds of frac sand. These wells have been drilled on 40-acre spacing. Only the Almond coals have been completed at Cow Creek.

To the east of Cow Creek, Anadarko Petroleum is producing 3622 Mcfd and 18,147 Bwpd (Nov. 2003) from 10 wells in their Sun Dog Pod in T16N-R91W (**Fig. 4**). These wells produce from depths of 800 to 1000 ft, on 80-acre spacing. Coals in both the Almond and Allen Ridge Formations have been completed in some wells. However, production is commingled so we don't know the contribution from individual seams. These wells have been stimulated with a small water frac with no proppant. South of Sun Dog, Anadarko has ten additional wells at the 24,878-acre Blue Sky Pod in T15N-R91W. Producing depths range from 2200 ft to 2750 ft. These wells were connected to the sales line in July, 2003 and are currently producing 330 Mcfd and 13,200 Bwpd.

During January, 2004, Merit Energy extended the play to the south by drilling five wells in the Brown Cow Unit in T14N-R91W. These wells contained between 70 and 100 ft of net coal, based on a bulk-density cutoff of 2.0 g/cc. The wells were drilled on 40-acre spacing, with coals at 1425 to 1825 ft. The wells are currently being completed, with hook-up to the

sales line planned for April 2004. The Allen Ridge coals will also be completed in some of these wells. Mud logs show very good gas increases across from all the coals, and gas bubbles are commonly seen desorbing from the coal cuttings.

Data from whole core and rotary sidewall cores in 13 wells indicate that these relatively low rank coals (high volatile C bituminous, with Ro of 0.48-0.51%) contain widely varying gas contents throughout the length of the play. Gas contents within the Almond coals range from 21 scf/t to 266 scf/t, on an as-received basis (arb). The Allen Ridge coals contain between 53 scf/t and 295 scf/t, (arb). To compare the gas measurements by the two different coring methods, Almond coals were sampled in one well with whole core and rotary sidewall cores at depths of 1252 ft to 1350 ft. Eleven whole-core samples contained an average of 241 scf/t (arb), while 12 sidewall-cores contained an average of 266 scf/t, (arb). Adsorption isotherms from coals in five wells indicate that both the Almond and Allen Ridge coals are fully saturated or slightly undersaturated.

The total coal thickness ranges from 40 to 100 ft, based on a bulk-density cutoff of 2.0 g/cc, at depths of 1100 ft to 2750 ft. Coals are present within a 700-ft-thick stratigraphic interval. The play may extend to the west to depths of 4000 ft and to the updip exposure of both coal groups to the east. The coals are over-pressured with pressure gradients of 0.48-0.67 psi/ft., and are commonly drilled with mud weights ranging from 10.3-12.3 pounds per gallon. Water quality within the coals ranges from 1000-1450 ppm total dissolved solids. Most of the produced water is injected into the Deep Creek sandstone at depths of 3000 to 4000 ft or Nugget sandstone at a depth of 9600 ft at rates of 5,000 to 10,000 Bwpd per well.

Potential reserves in coals of both formations may be as high as 3.0 Bcf per well, based on 160-acre spacing. Most wells are only producing from coals within the Almond formation

COW CREEK FIELD

Atlantic Rim CBM Play, Carbon County, Wyoming

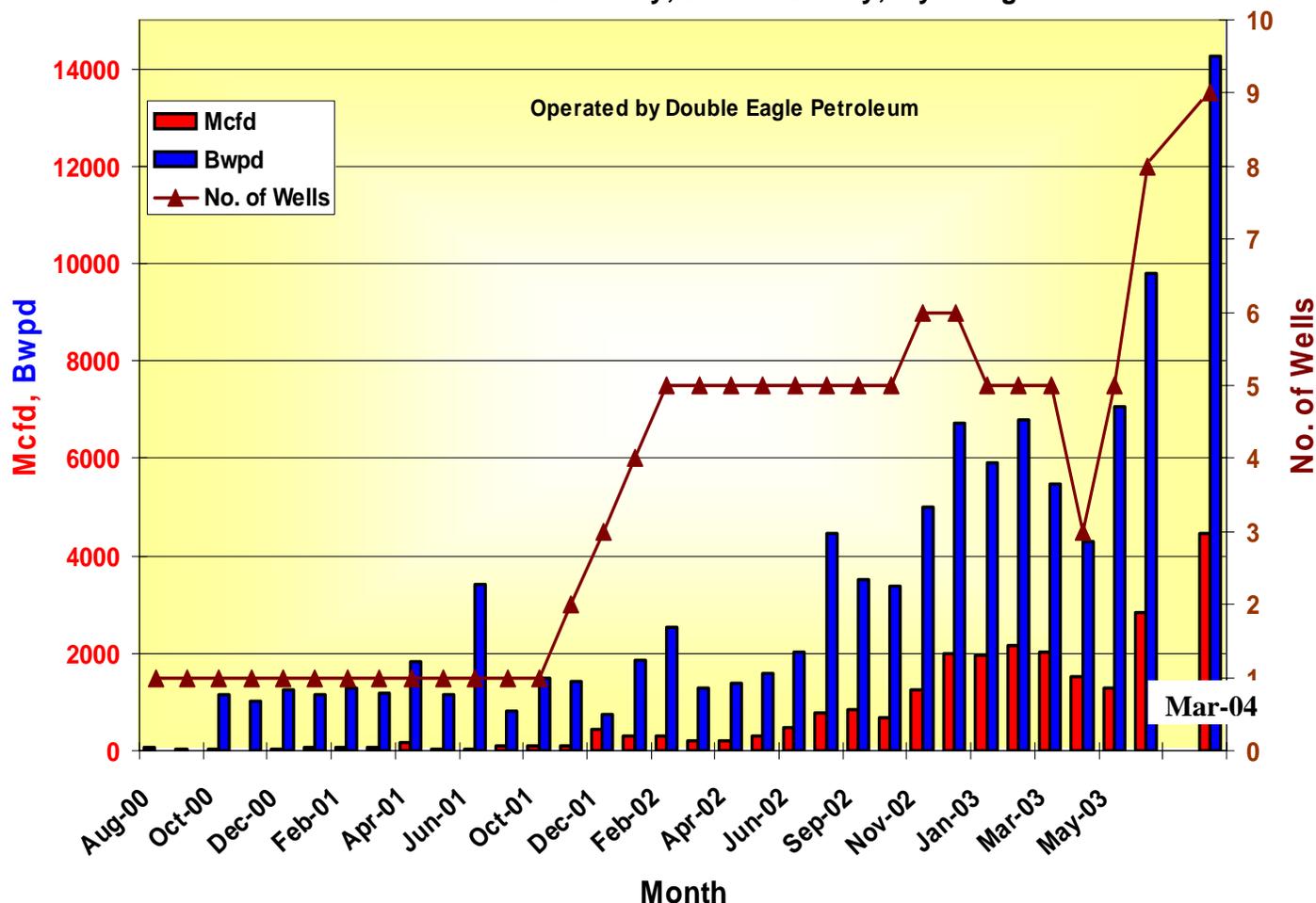


Figure 1. Nine wells produced 4453 Mcfd and 14,240 Bwpd at Cow Creek Field during November 2003.

where the reserves may be 2.0 Bcf per well, based on 160-acre spacing. The gas contains less than 0.5% CO₂ and has a heating value of 990-1000 Btu/cf. All produced gas is being compressed and sold into a 12-inch pipeline that traverses the play area.

Coal permeability has not been measured in the field, but the high (up to 3000 Bwpd per well) water production rates indicate that permeability is very good. The producing wells are on the west side of the Atlantic Rim Play, near a structural hingeline separating 6° dips on the west from 3° dips on the east. Fractures associated with this structural anomaly are probably responsible for the high permeability. Cow Creek produces from a four way closure, Sun Dog is on a structural nose and Blue Sky produces from just regional, westerly dip. This suggests that folding may not be required to provide sufficient permeability in these shallow coals.

The over-pressuring and unusually high gas contents of these coals are probably related. We suspect that the play is a large stratigraphic trap, with the gas being held in place by

down dip flow of meteoric water from the high Sierra Madres to the east. This influx of fresh water (30 inches of precipitation per year) has probably also contributed biogenic gas to the coal reservoir. Coals and carbonaceous shales that are deeply buried near the center of the Washakie Basin to the west are generating thermogenic gas today. Some of this gas has probably migrated updip to the east to help form the large coalbed methane occurrence that is currently being exploited.

Producibility of the coals in the northern portion of the play will be tested in two areas during 2004. Anadarko and Double Eagle plan to drill 24 production wells and two disposal wells at the Doty Mountain Pod in T17N-R91W. These wells will test Almond and Allen Ridge coals at depths of 2275 to 3100 ft. Anadarko and Warren E&P will drill eight producers and two disposal wells at the Red Rim Pod near the northern limit of the trend in T20N-R89W. These wells will also test both coal groups.

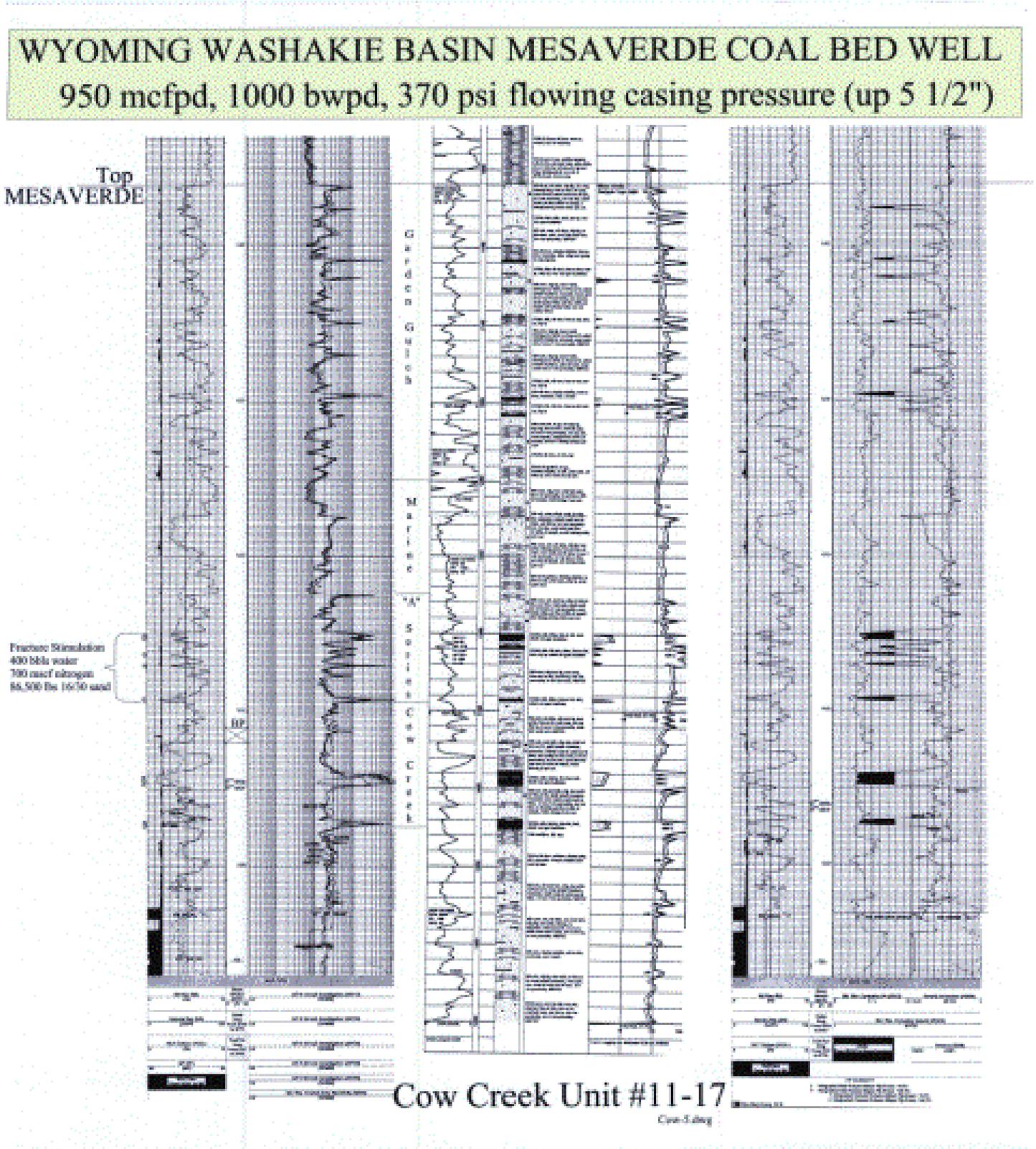


Figure 2. Logs showing a typical coal-bearing Almond section at Cow Creek Field. Test data for this well are shown in the heading. (Slide from S. Hollis, Double Eagle Petroleum).

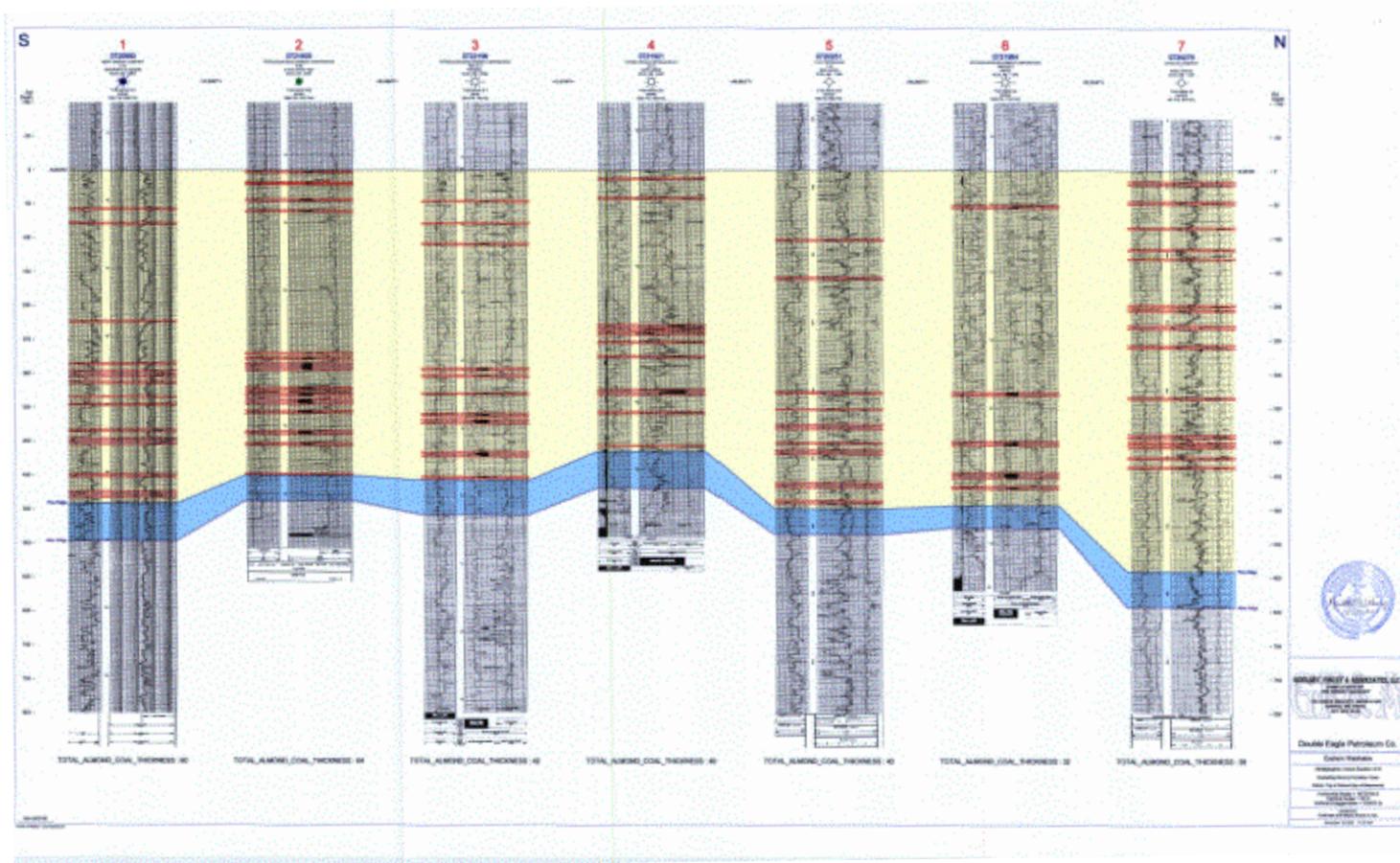


Figure 3. Log cross-section showing continuity of Almond coals across Cow Creek Field. Coals are highlighted in red and marine shoreline sandstone is shown in blue.

Early results from the Atlantic Rim CBM Play suggest that the relatively-low rank coals within the Mesaverde Group are capable of storing sufficient natural gas to be economic producers. Additional exploration is justified along the margins of the Greater Green River Basin and around the Rock Springs Uplift. Fully saturated coals will probably only be found in areas where structure, hydrodynamics and a change in pressure regimes allow secondary biogenic gas and migrated thermogenic gas to re-saturate the coals.

ANADARKO-SUN DOG POD

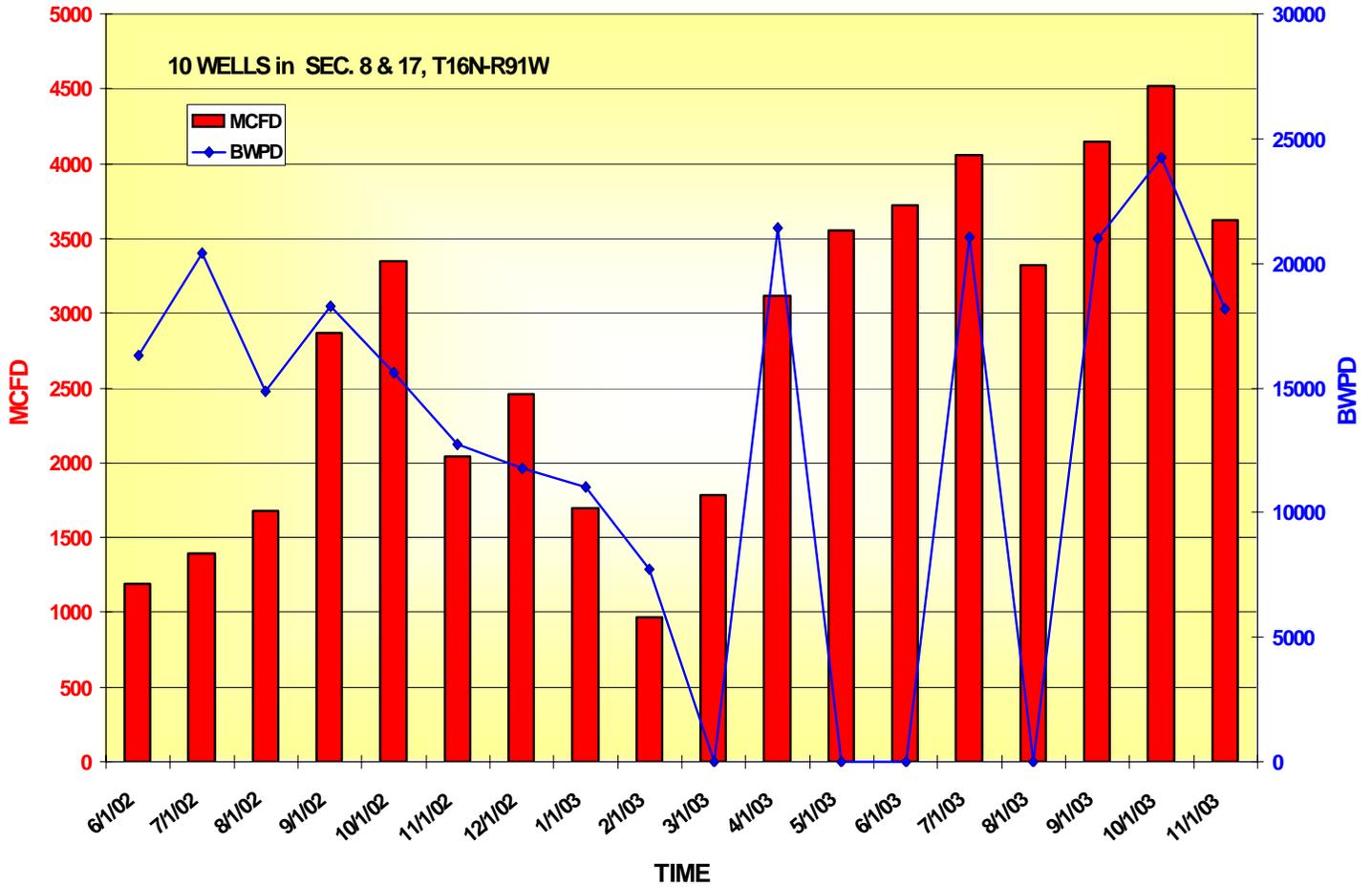


Figure 4. Sun Dog Pod produced 3622 Mcfd and 18,147 Bwpd during November 2003.