# CHAPTER 5
# CONCLUSION AND RECOMMENDATIONS

## 5. 1 CONCLUSION

The following conclusions could be drawn from the study conducted:

a) Multistage Centrifugal Pumps are the type of injection pumps suitable for high pressure and high flow rate reservoirs due to their reliability and low maintenance cost as compared to the Positive displacement reciprocating pumps.

b) Pressure Maintenance is achieved with the Line Drive water Injection Pattern used in this project. This process might be improved by combining with other patterns of injection and by considering not injecting only water but also injecting miscible gas.

c) The Wells borehole pressure is improved when injecting equal number of water injection wells and producers. The ratio between the injected water and the Oil produced is about two (I/P =2 STB) barrels of water per 1STB of oil produced, which is not typical for line drive injection pattern.

## 5.2 RECOMMENDATIONS

a) Combining Line drive injection with staggered injection should be analyzed.
b) Further studies on the use of the Simulation software is required to better use and interpretation of the results obtained for each simulation work.

## REFERENCES


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# APPENDICES

**APPENDIX A: PUMPS SEGMENT Matrix by SULZER Pumps [9]**

| Product Types | | Oil & Gas | Hydrocarbon Processing | Pulp & Paper | Power Generation | Water & Wastewater | Food, Metals & Fertilizers |
|---|---|---|---|---|---|---|---|
| Single Stage Pumps | AHLSTAR™ A Series | | ● | ● | ● | ● | ● |
| | AHLSTAR™ N Series | | ● | ● | | | ● |
| | AHLSTAR™ W Series | | ● | ● | ● | | ● |
| | AHLSTAR™ E Series | | ● | ● | ● | | ● |
| | CPT | | ● | ● | ● | | ● |
| | Z Series | | ● | ● | ● | ● | ● |
| | OHH/OHHL | ● | ● | | | | |
| | OHM/OHC | ● | ● | | | | |
| | BBS | ● | ● | | | | |
| | HLTE | | ● | | | | |
| | HZB | | | | ● | | |
| Two Stage Pumps | BBT/BBT-D | | ● | | | | |
| | LSP/LST | | | ● | | | |
| Barrel Pumps | GSG | ● | ● | | ● | | ● |
| | HPT | | | | ● | | |
| | HPcp/HPcpV | ● | | | | | |
| | CP | ● | ● | | ● | | |
| | MPP | ● | | | | | |
| Ring Section Pumps | M Series | | | ● | ● | ● | ● |
| | HPP/HPT | | | ● | ● | ● | ● |
| | HPH/HPL | | | | | ● | ● |
| | TUP | | | | | ● | |
| Axial Split Pumps | MSD | ● | ● | | ● | | |
| | SM/SMN/SMH Series | ● | ● | ● | ● | ● | ● |
| | HSB | ● | ● | | | | |
| | ZPP | | | ● | ● | | |
| | HPDM | ● | | | | ● | |
| Vertical Pumps | AHLSTAR™ NVP/NVT | | ● | ● | ● | ● | ● |
| | AHLSTAR™ NKP/T,WKP/T | | | ● | | | ● |
| | B Series | ● | ● | | ● | ● | |
| | JD | ● | ● | ● | ● | ● | ● |
| | JF | ● | ● | ● | ● | | ● |
| | JM | | ● | ● | ● | ● | ● |
| | JP | | ● | ● | ● | ● | ● |
| | JS | ● | ● | ● | ● | ● | ● |
| | JT | ● | ● | ● | ● | ● | ● |
| | OHV | ● | ● | | | | |
| | VCR | ● | ● | | | | |
| | TTMCM | | ● | | | | |
| | APV/NPV | | | | ● | ● | |
| MC® Products | MC® Pumping System | | | ● | | | |
| | AHLMIX™ Chemical Mixer | | | ● | | | |
| | MC® Discharge Scraper | | | ● | | | |
| | MC® Flow Discharger | | | ● | | | |
| Agitators | SALOMIX® SL/ST | | | ● | | | ● |
| | SALOMIX® L Series | | | ● | | | ● |
| | SALOMIX® TES, VULCA | | | ● | | | |
| Service | Service products available for all segments. | | | | | | |

## APPENDIX B: DIFFERENT TYPES OF INJECTION PUMPS

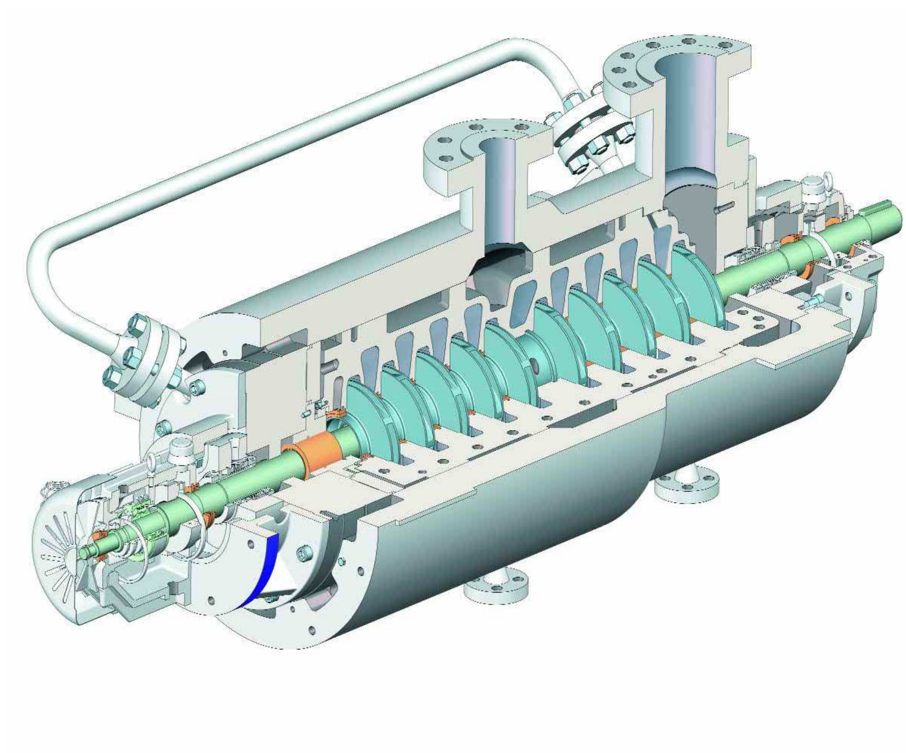

**Figure B1: CP Horizontal Double Casing Radially Split Multistage Pump [9]**

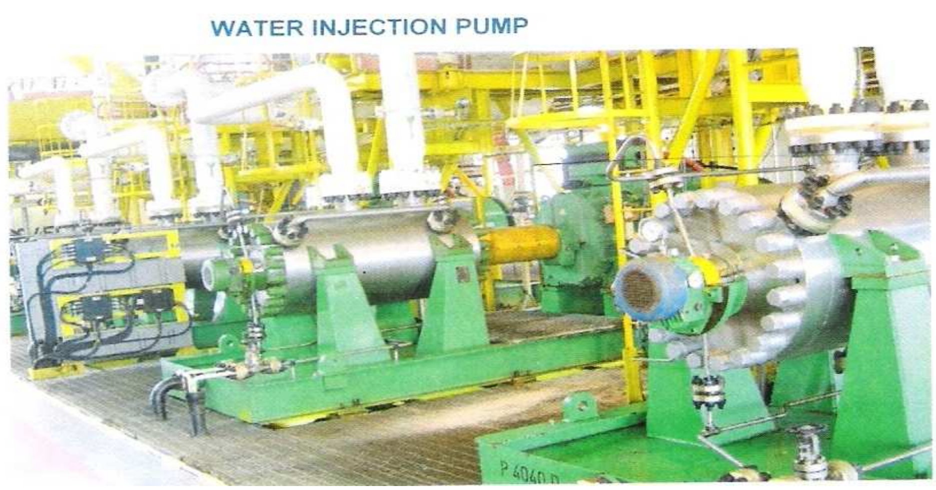


**Figure B2: CP horizontal Pumps used in Angsi Field, Malaysia [19]**

## APPENDIX C: GELAMA MERAH RESERVOIR PVT PROPERTIES

**Table C: Gelama Merah Reservoir Model PVT Properties**

| Parameter | Unit | Description |
|---|---|---|
| Gas oil Contact (GOC) depth | Feet (ft) | 4815.945 |
| Water Oil Contact(WOC) depth | Feet | 4948.163 |
| Reservoir Thickness | Feet | 132.218 |
| Maximum Reservoir Pressure | psi | 2200 |
| Number of cells | ---- | 53x44x104 |
| permeability | md | 20-200 (average) |
| | | |
| **Live Oil Properties** | | |
| Oil Density | lb /cu ft | 51.85 |
| Oil Viscosity | Centipoises (cp) | 2.938 |
| Oil Saturation, So | Percentage (%) | 0.37328 0r 37.328 % |
| Oil Volume Factor, Bo | Rb/STB | 1.15 |
| Specific Gravity | (Oil density/Water Density) | 0.83 |
| API Gravity | Degree API | 38.87 |
| | | |
| **Dry Gas Properties** | | |
| Gas density | lb/cu ft | 0.0522 |
| Gas Saturation, Sg | Percentage (%) | 0.56 or 56.0% |
| Gas viscosity | cp | 0.0266 |
| | | |
| **Water Properties** | | |
| Water Volume Factor, Bw | Rb/STB | 1.0 |
| Pressure at Water level | psi | (1874 to 21116.463) |
| Water Viscosity | Centipoises (cp) | 3.561e-006 |
| Water Density | lb/cu ft | 62.43 |
| Water Saturation | Percentage (%) | 0.18664 or 18.6% |
| | | |
| **Reservoir Rock Properties** | | |
| Average Pressure, | Psia | 1874 |
| Porosity | % | 20 |

## APPENDIX D: 3D Views of the Simulation Work

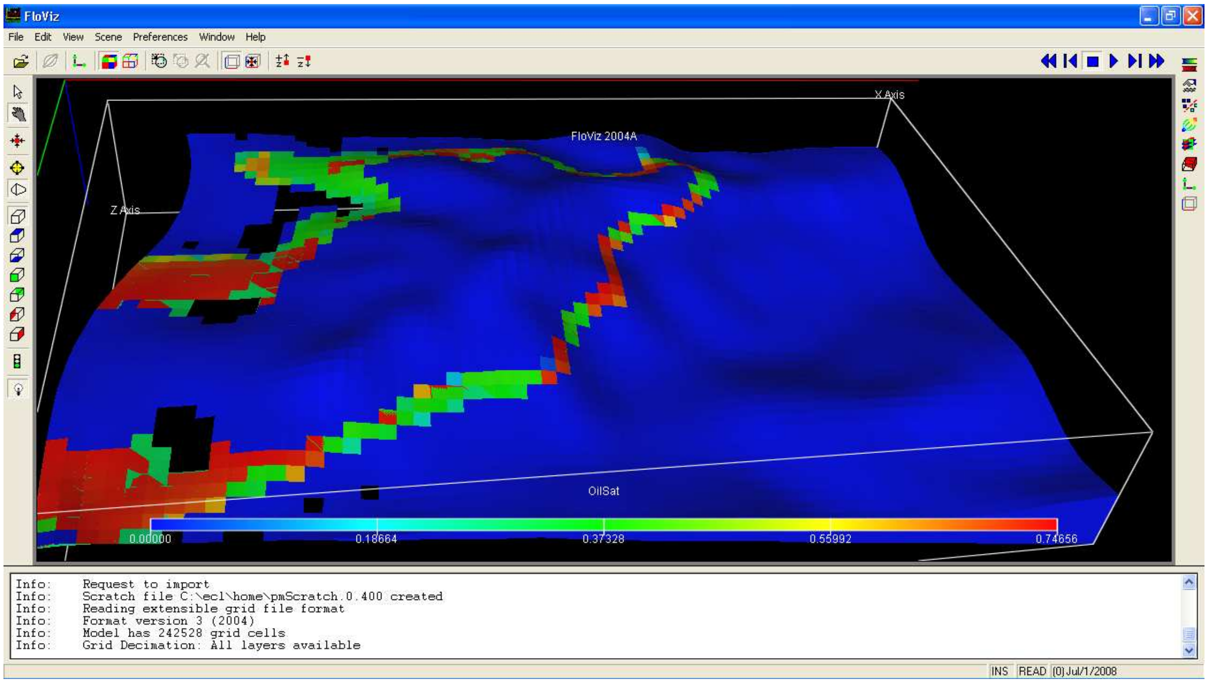


**Figure D1: Top View of the Reservoir Model Before well designs**

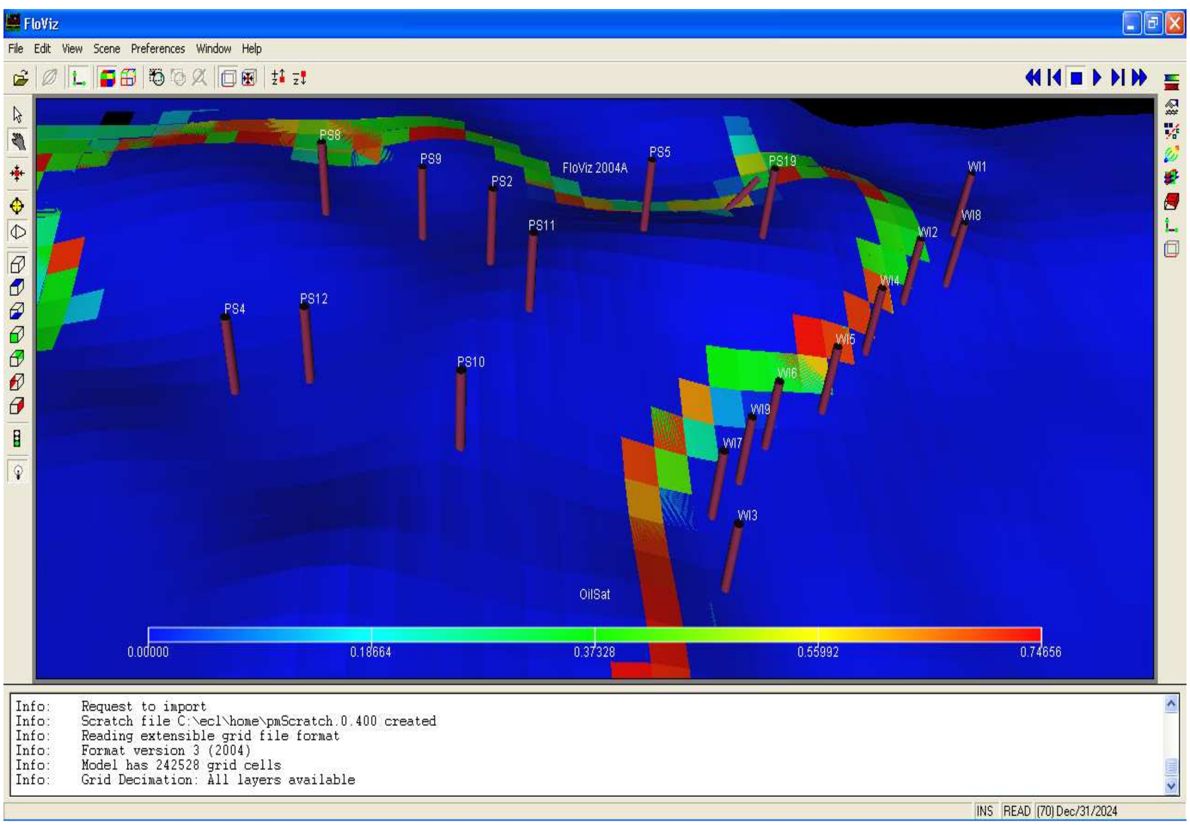


**Figure D2: Top view Of the Reservoir Model after wells design**

## APPENDIX D: 3D Views of the Simulation Work (continue)

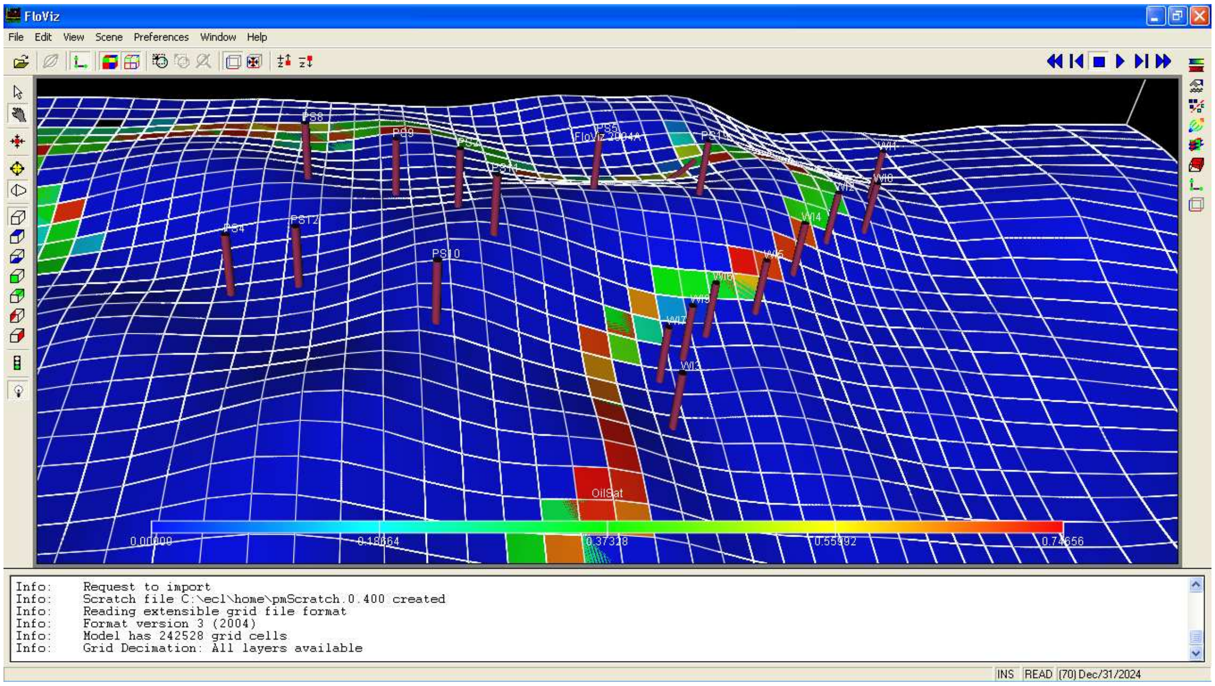


**Figure D3: Grid view of the Reservoir Model**

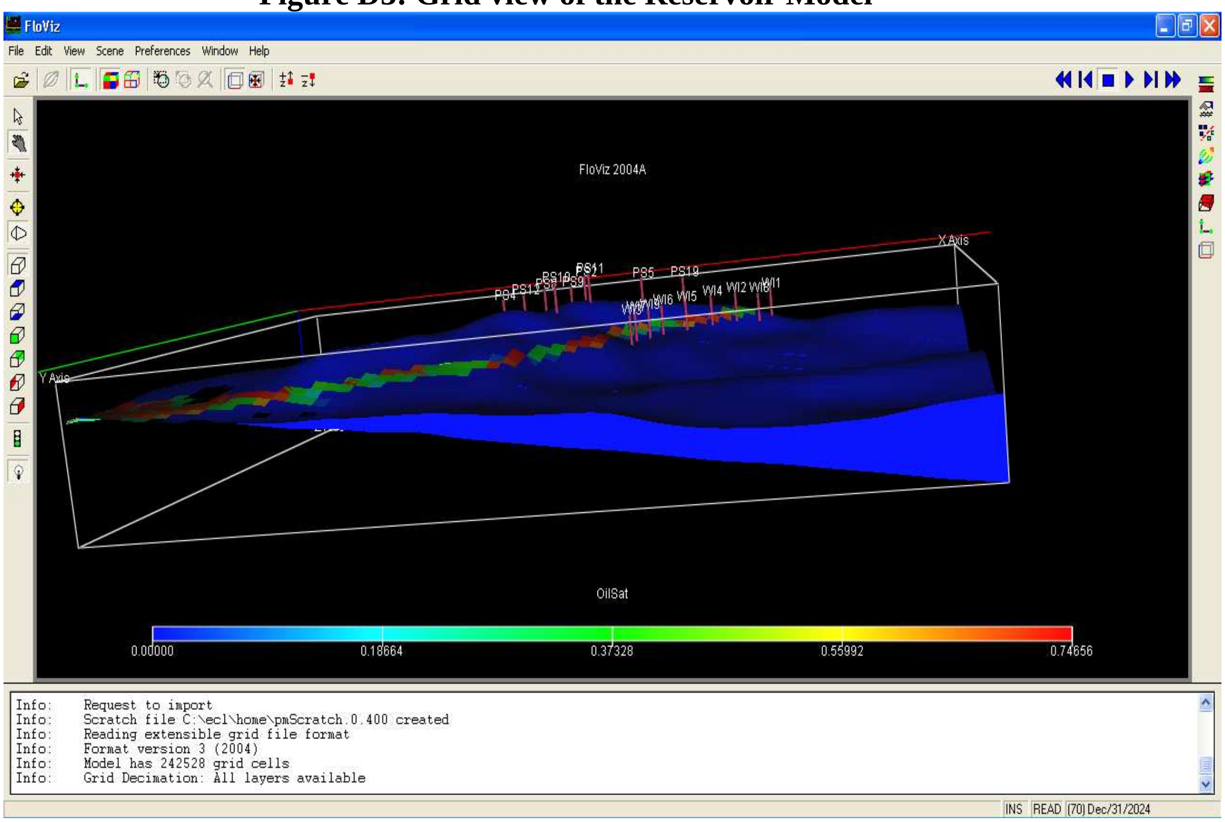


**Figure D4: Side View of the Reservoir Model**

## APPENDIX D: 3D Views of the Simulation Work (continue)

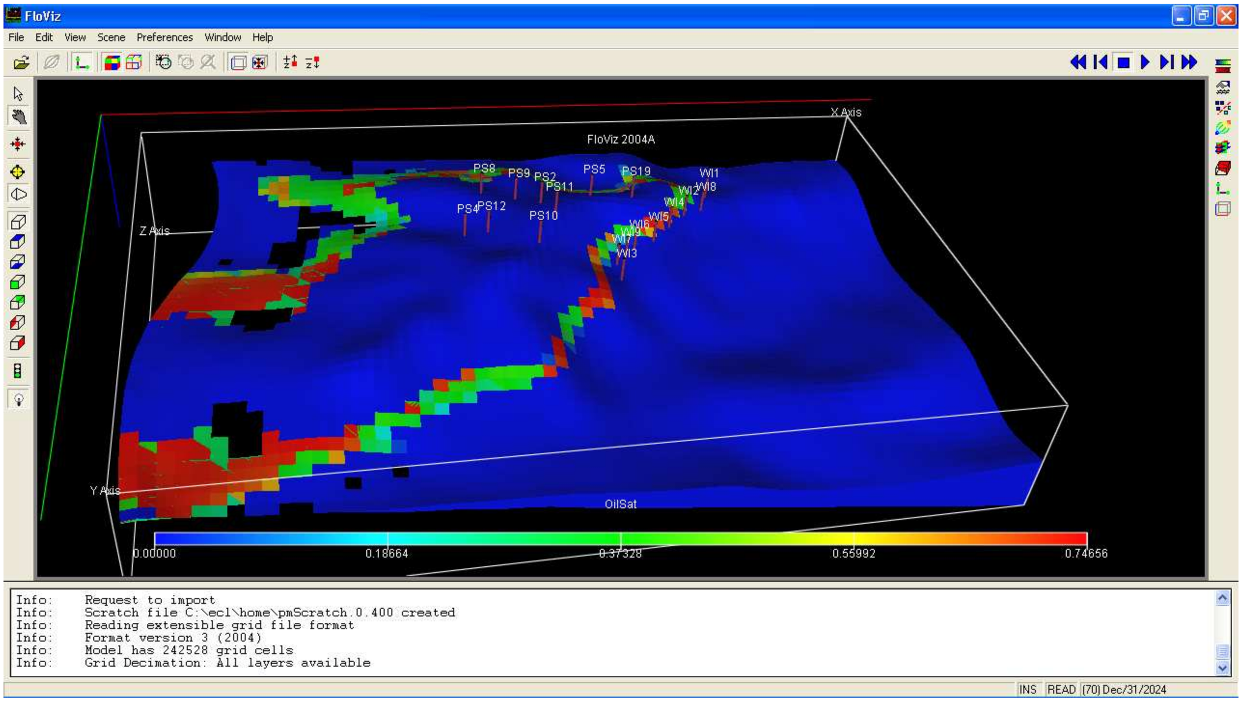


**Figure D5: Top view of The Model**

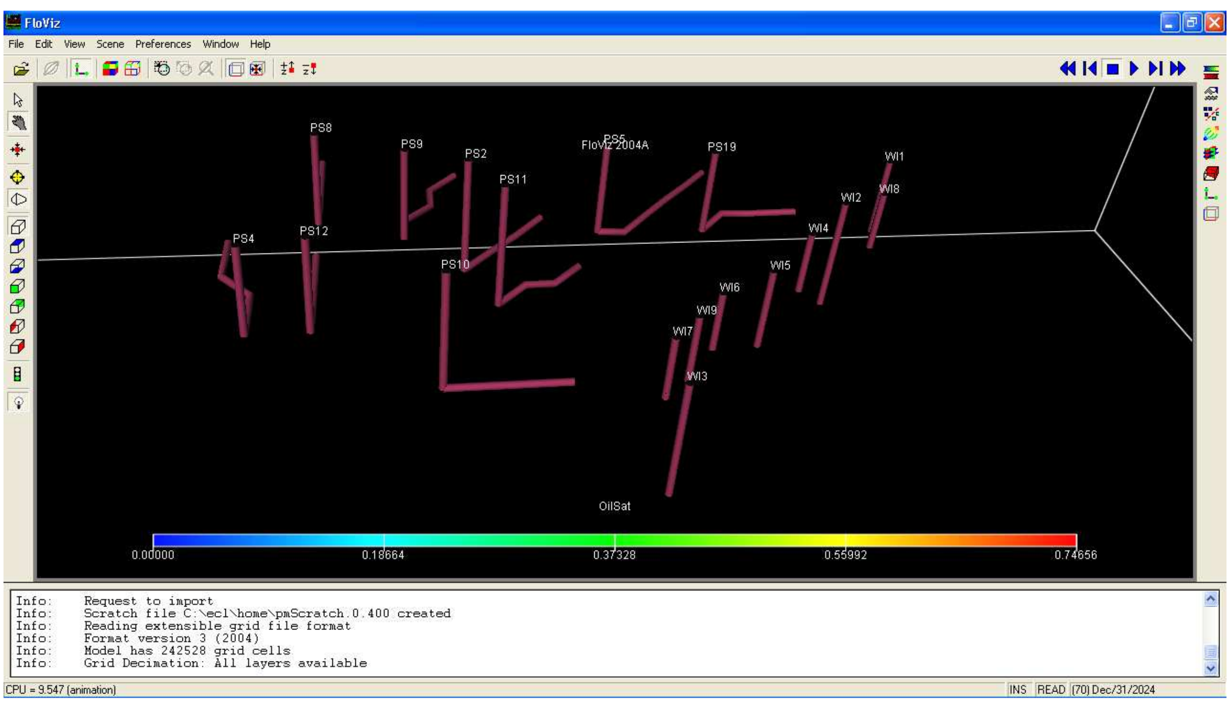


**Figure D6: Wells Layout of the Model**