Energy and Environmental Systems Group
Institute for Sustainable Energy, Environment and Economy (ISEEE)

Water Disposal Well Analysis

Wabamun Area CO_2 Sequestration Project (WASP)

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1	August 3, 2009	First Draft Report	Rob Lavoie
2	December 21, 2009	Second Draft Report	Rob Lavoie

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INTRODUCTION

BACKGROUND

One of the most useful methods of characterizing the quality of a reservoir for its deliverability or injectivity is to make use of analogues from similar or adjacent areas to the area of study. The production and injection history in the analogue pool or wells can be assessed for possible similarities to the study area formation. The Wabamun Area CO_2 Sequestration Project (WASP) study area is an entire 53 township of land area over top of a large portion of the Nisku aquifer in central Alberta, Figure 1. This study area was chosen intentionally to avoid existing hydrocarbon production. As such, there are no depleted pools or mature oil fields producing from the Nisku horizon in the entire study area. Nor are there any water disposal wells into the Nisku formation in the study area.

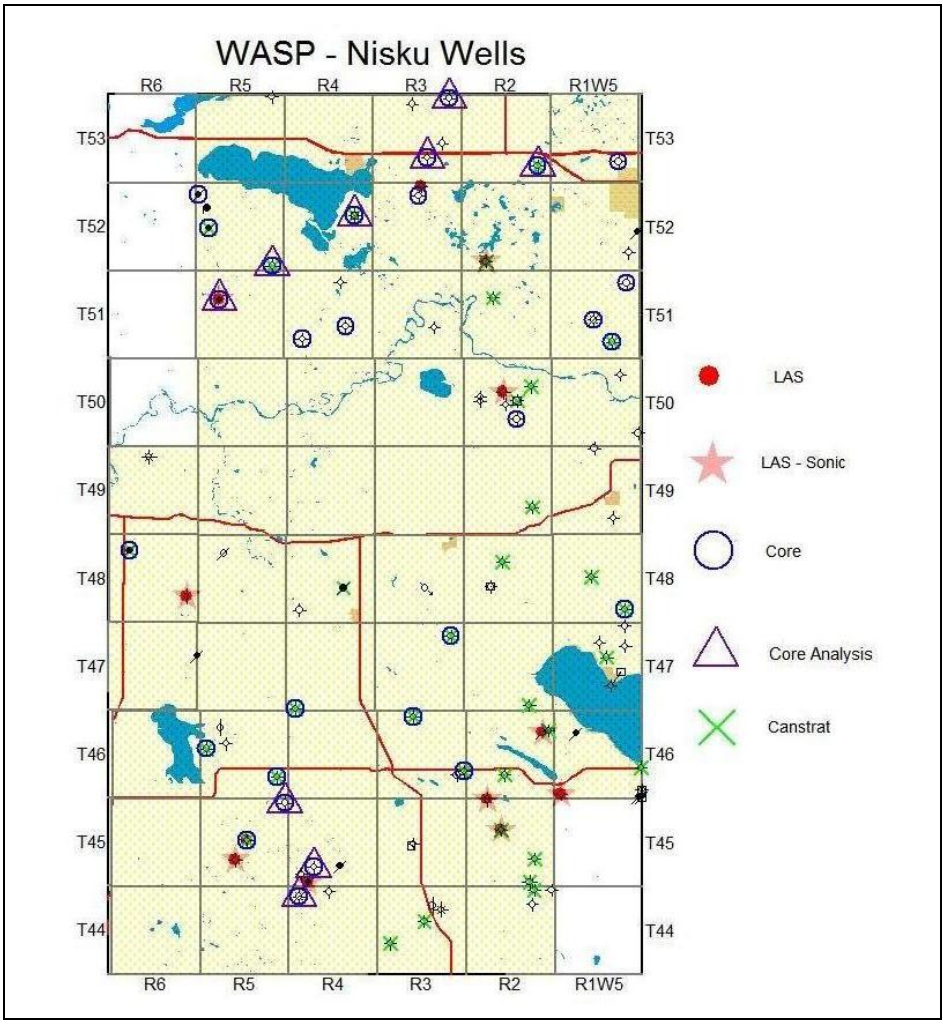


Figure 1: WASP study area

The WASP study team was able to find one water source well in the study area, as is discussed in other section of the WASP documentation. However, this source well is operated with an electrical submersible pump and there are no bottom hole pressure instruments to determine the production drawdown associated with brine production. This results in an inability to assess the deliverability parameters for this well. The operators of the well gave assurances that the drawdown is minimal and an independent assessment of this location performed by WASP indicates that a very high deliverability exists for this one well.

In an attempt to find additional confirmation of good reservoir quality conditions for the Nisku aquifer, a review of water disposal wells in a study area consisting of 30 townships immediately to the east of the WASP study area was performed. Figure 2 highlights this area along with the locations of six major Nisku oil and gas pools.

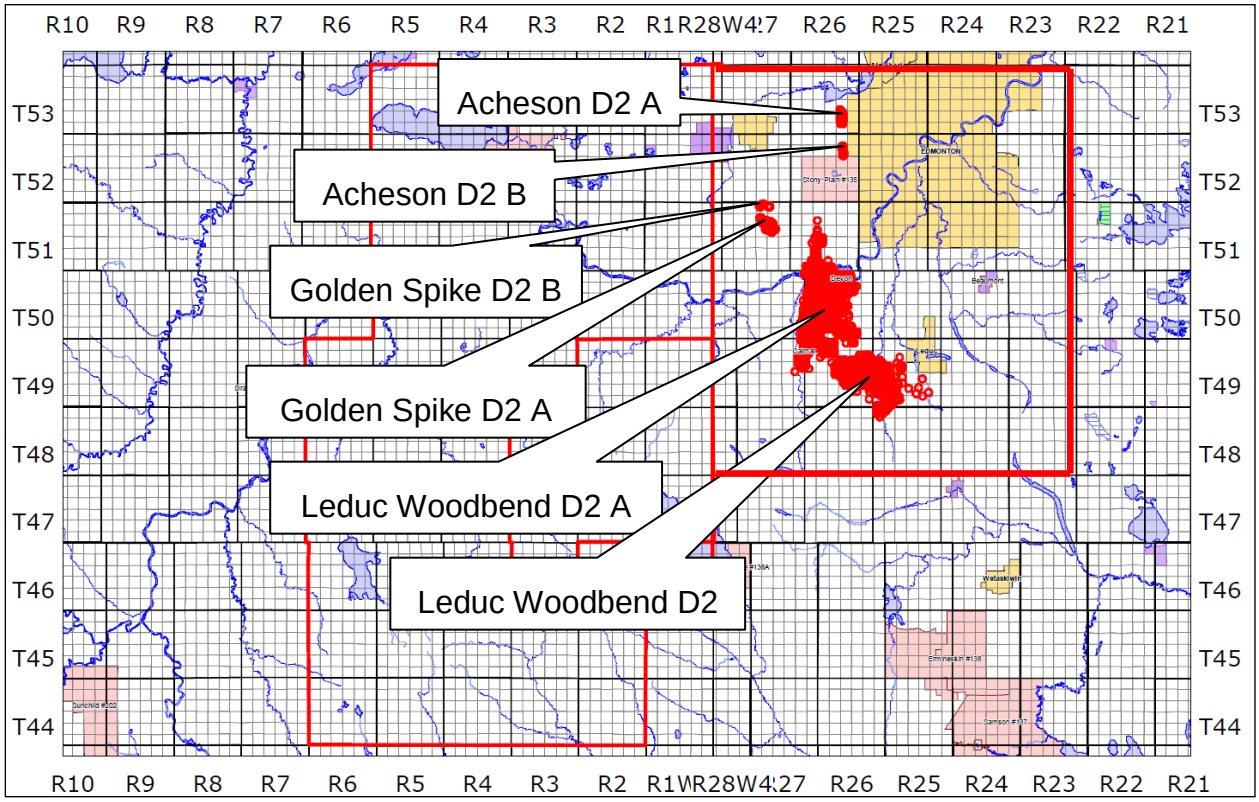


Figure 2: Water disposal well study area

The discussion that follows provides a summary of the water disposal well operating rates for wells located in this study area.

DISCUSSION

1. ESTIMATED PER WELL CO_2 INJECTION VOLUMES

A benchmark for estimated injectivity requirements for future commercial CO_2 sequestration projects would be helpful for comparison to water disposal volumes. Table 1 provides a listing of Nisku Aquifer conditions and an estimate of the injection volume requirements at reservoir conditions to dispose of 1 Mt of CO_2 per year:

Table 1: Nisku aquifer characteristics and CO_2 volume at aquifer conditions.

Description	Value	Unit of Measure
Reservoir Temperature	60	Deg. C
Reservoir Pressure	16,000	kPa
CO_2 Density @ Res. Cond.*	595	Kg/m^3
1 Mega Tonne/Yr	2,740	Tonnes/day
Injection Rate	4,605	m^3/day at res. cond.
Total injection over 50 years	84 million	m^3 at reservoir conditions
* Based on the Peng-Robinson equation of state at stated conditions using the web application published at http://esdtools.lbl.gov/cgi-bin/webgaseos.cgi		

The reservoir volume of CO_2 to be sequestered on a per well basis is in the order of 84 million m^3 at reservoir conditions of 16 kPa and 60 deg. C. The volume injected on a daily basis would be 4,605 m^3. These volumes are large in comparison to historic injection rates observed for Nisku disposal wells—as reported below.

2. STUDY AREA WATER DISPOSAL WELLS INTO THE NISKU AQUIFER

A total of 98 water disposal wells were found for the subject study area. Figure 3 provides a comparison of the cumulative injection volumes associated with each of these wells.

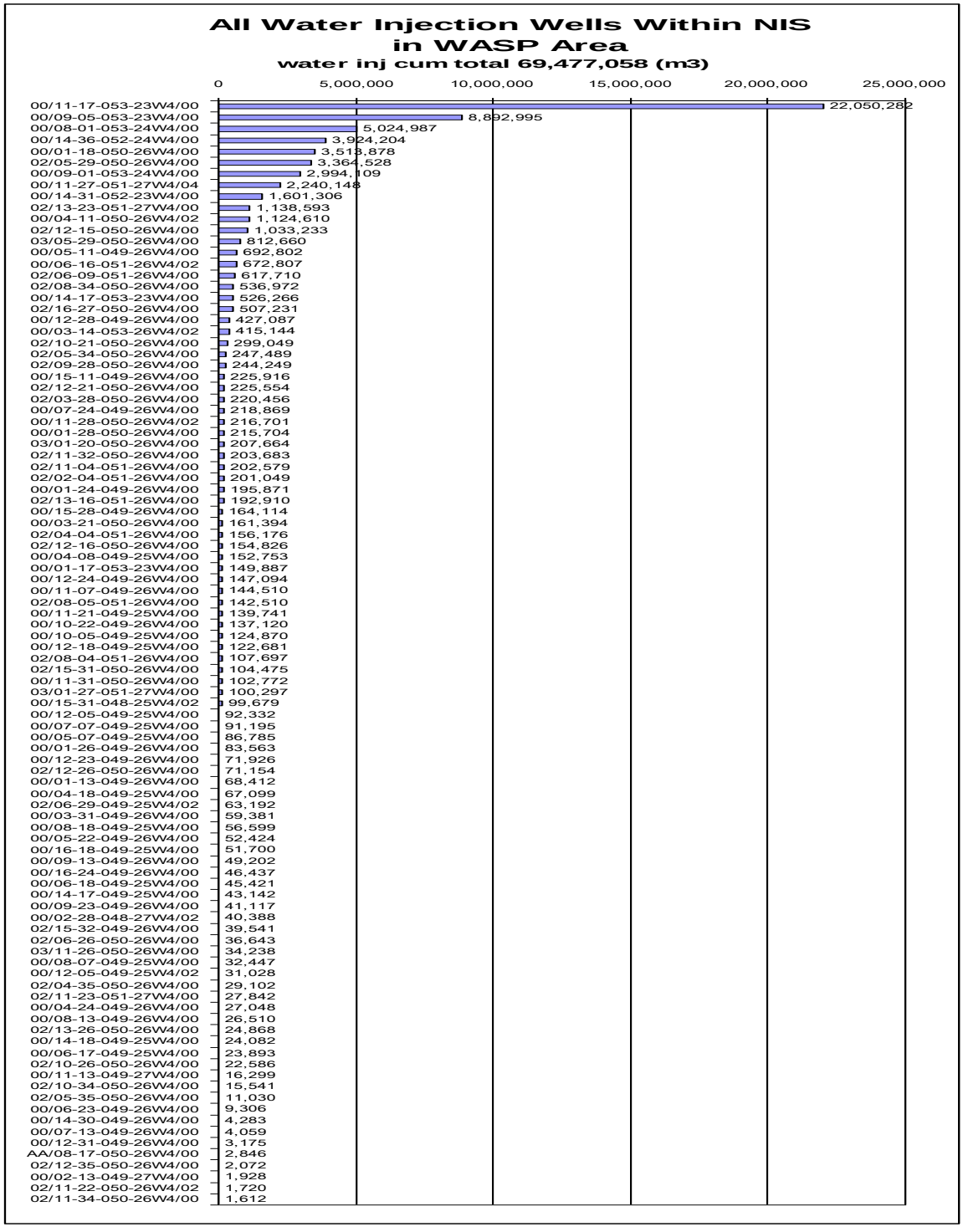


Figure 3: List of water disposal wells in study area.

Figure 4 provides a map of the locations of the top 19 wells in this list.

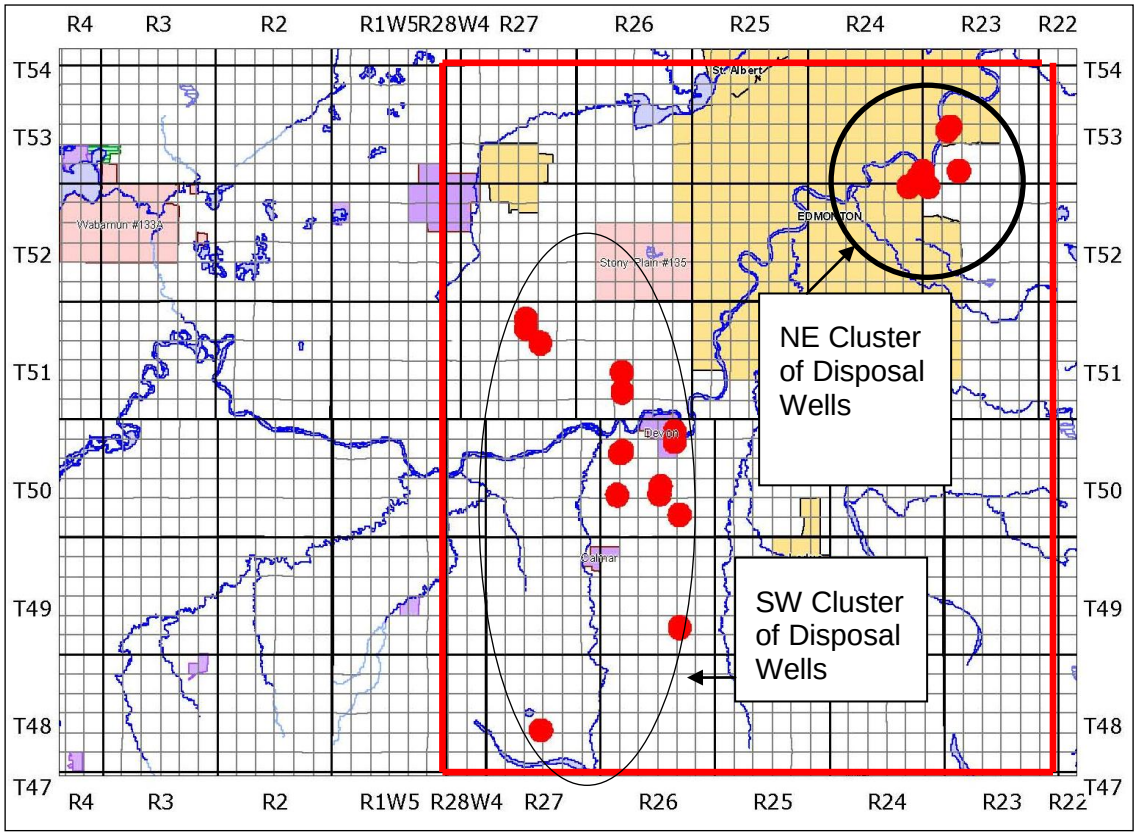


Figure 4: Location of top 19 water disposal wells in study area.

As can be seen on this map, two clusters of wells are evident. The NE cluster is located near the industrial parks of northeastern Edmonton. The SW cluster is located in the Nisku oil and gas pools SW of Edmonton.

Figure 5 provides a closer look at the cumulative volumes injected for the top 19 disposal wells. As can be seen from this diagram, the largest disposal well is located in the cluster to the north east of Edmonton. In fact, disposal wells located in this region generally have higher cumulative volumes relative to those located in the Nisku oil and gas fields to the south west of Edmonton. It is not possible to assess rigorously the injectivity parameters for these wells, but by inference only, it seems likely that the north east cluster wells have higher total injectivity. This is consistent with a geological interpretation of the Nisku aquifer that suggests there are better reservoir parameters in the vicinity of the north east cluster (Reference 1).

For the purpose of our search for analogue injectivities, the south west cluster of wells is deemed to be more representative of the reservoir characteristics associated with the WASP study area. The largest cumulative volume injected in the south west well cluster is in the order of 3.5 million m^3. This is significantly lower that the 84 million m^3 that would be required for a single CO_2 sequestration well with an injectivity of 1 mega tonne per yr.

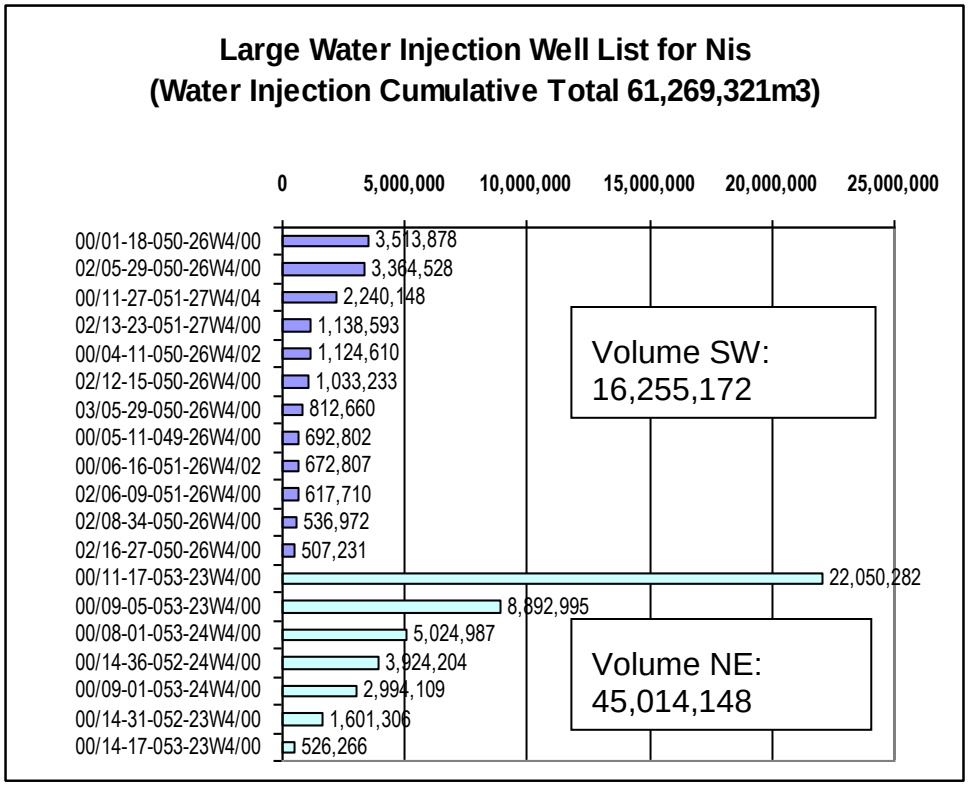
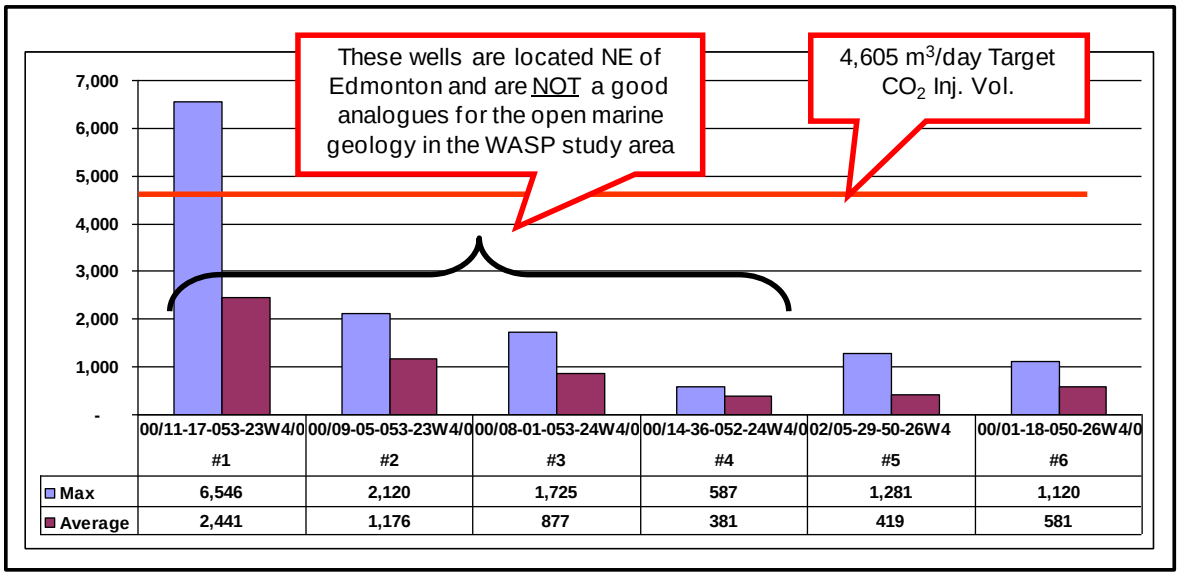


Figure 5: Plot of cumulative volumes for top 19 disposal wells.

3. WATER DISPOSAL WELL INJECTIVIES

A review of the maximum and average injection rates associated with the water disposal wells is provided in Figure 6.



	00/11-17-053-23W4/0 #1	00/09-05-053-23W4/0 #2	00/08-01-053-24W4/0 #3	00/14-36-052-24W4/0 #4	02/05-29-50-26W4 #5	00/01-18-050-26W4/0 #6
Max	6,546	2,120	1,725	587	1,281	1,120
Average	2,441	1,176	877	381	419	581

Figure 6: Top six water disposal wells—daily injection rates (m^3/day).

As can be seen from Figure 6, daily injection rates of Nisku disposal wells located in the south west cluster of disposal wells are well below the reservoir volumes anticipated for a one mega tonne per year CO_2 disposal well. Once again, these results are qualitative only. It is not possible to determine the injection parameters associated with these rates from public domain data alone.

Figure 7 illustrates the location of well #6 (01-18-050-26W4) located in the south west cluster of injectors. Figure 8 provides the injection rate history plot for this well. As can be seen from the plot, injection rates were typically in the range of 1000 m^3 per day. This is about 20% of the anticipated requirement for a CO_2 disposal well, as illustrated in Figure 8.

It is not possible to conclude that these injection rates were at a maximum operating condition for the wells studied. However, given that numerous water injectors were developed for each oil pool, one could speculate that this is based on water injection capacity limitations and that these wells (or most of them) are at their capacity limitation. Further information would need to be acquired from oil company files to verify this assumption.

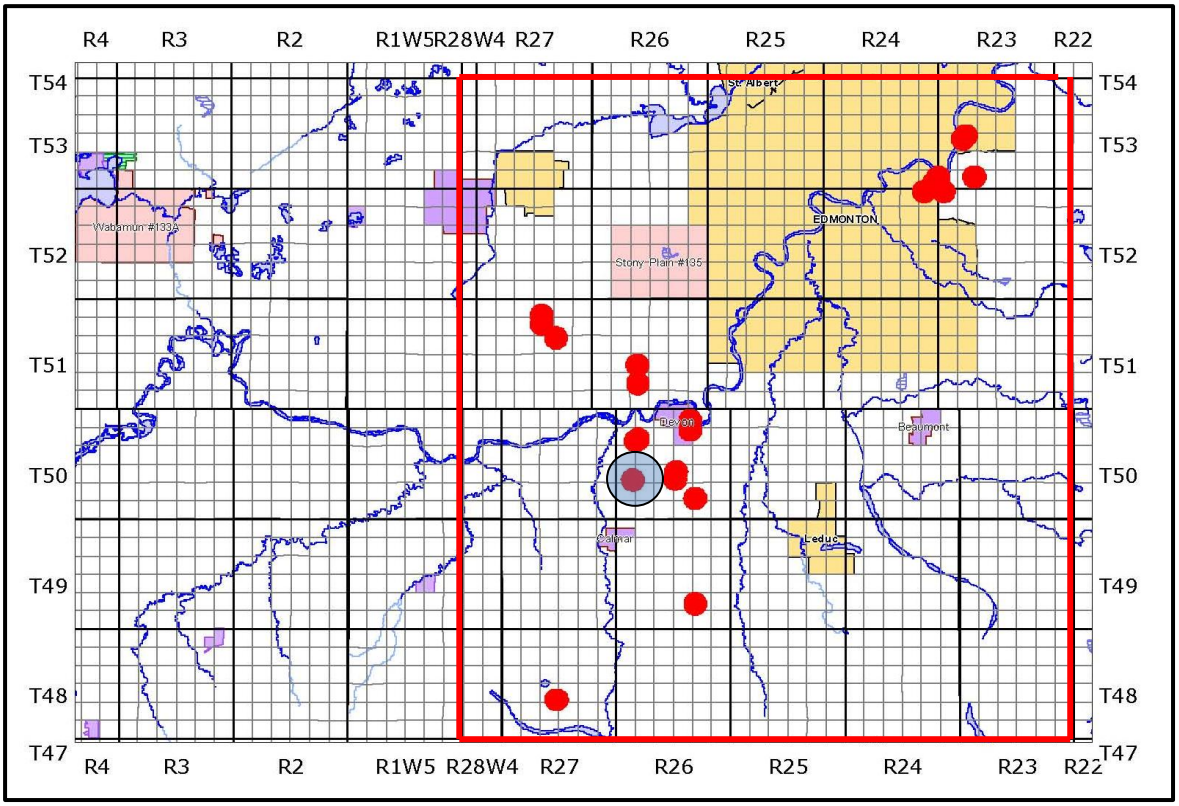


Figure 7: Location of Well #6 from Figure 6.

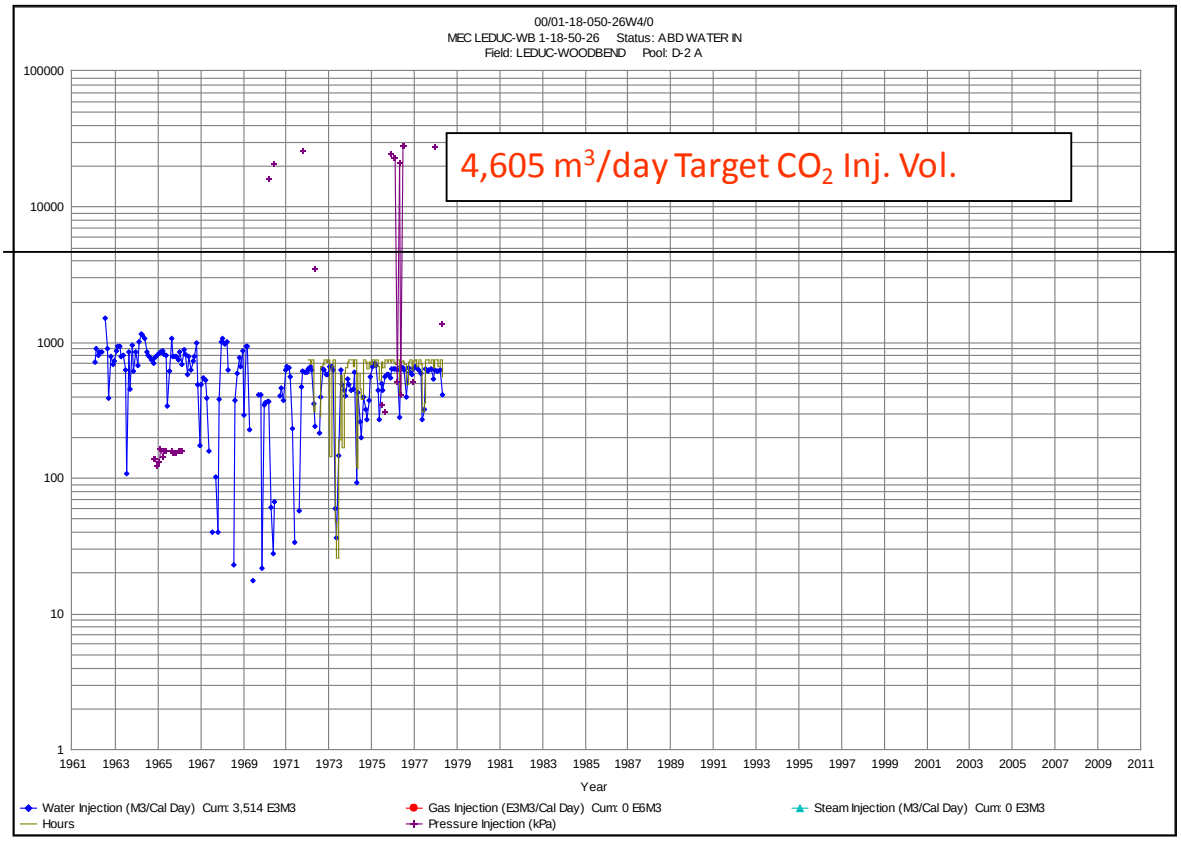


Figure 8: Typical injection performance history for Nisku water disposal well located in Nisku oil and gas accumulations adjacent to WASP study area.

4. PRESSURE HISTORY FOR DISPOSAL WELLS

Injection rates only tell part of the story, it is also important to understand the reservoir pressure these wells are injecting against. Figure 9 provides a typical pressure time history for the wells associated with this injectivity study.

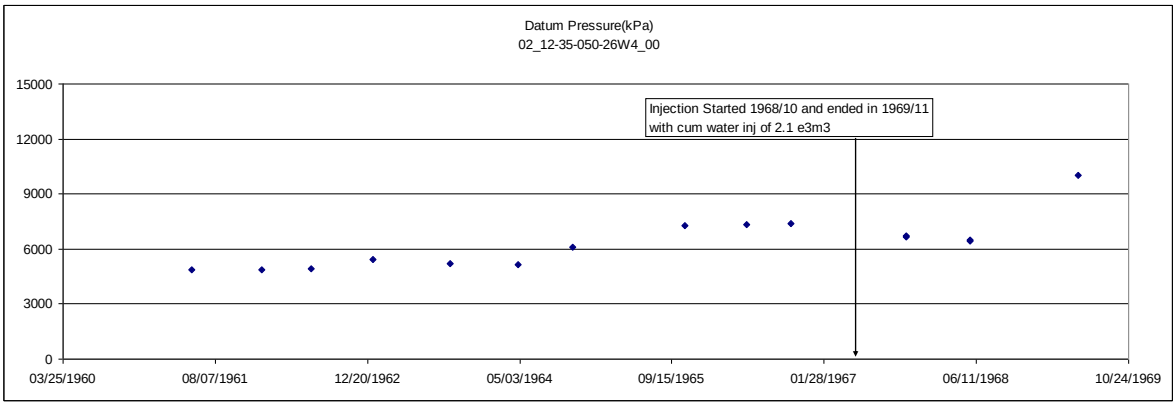


Figure 9: Pressure time history for a typical water disposal well in the south western set of disposal wells.

Figure 9 demonstrates the increase in pressure observed after a few years of injection into the water disposal wells located in the south west region of the disposal well study area. This was typical of all disposal well histories where adequate pressure history was collected. The pressure history for all wells in the Nisku oil and gas pools adjacent to the WASP study area is provided in Figure 10.

Figure 10 provides the pressure time history for all oil and gas wells located in the Nisku pools adjacent to the WASP study are. These pressure trends illustrate that some pools experienced a pressure decline during depletion of the pool but that pressure maintenance schemes in the later life of these pools successfully increase the reservoir pressure to near the original discovery pressures. Some of the Nisku oil and gas pools recorded very little pressure depletion. This is indicative of a very strong aquifer underlying these oil pools. This is discussed further in the material balance report accompanying the WASP documentation.

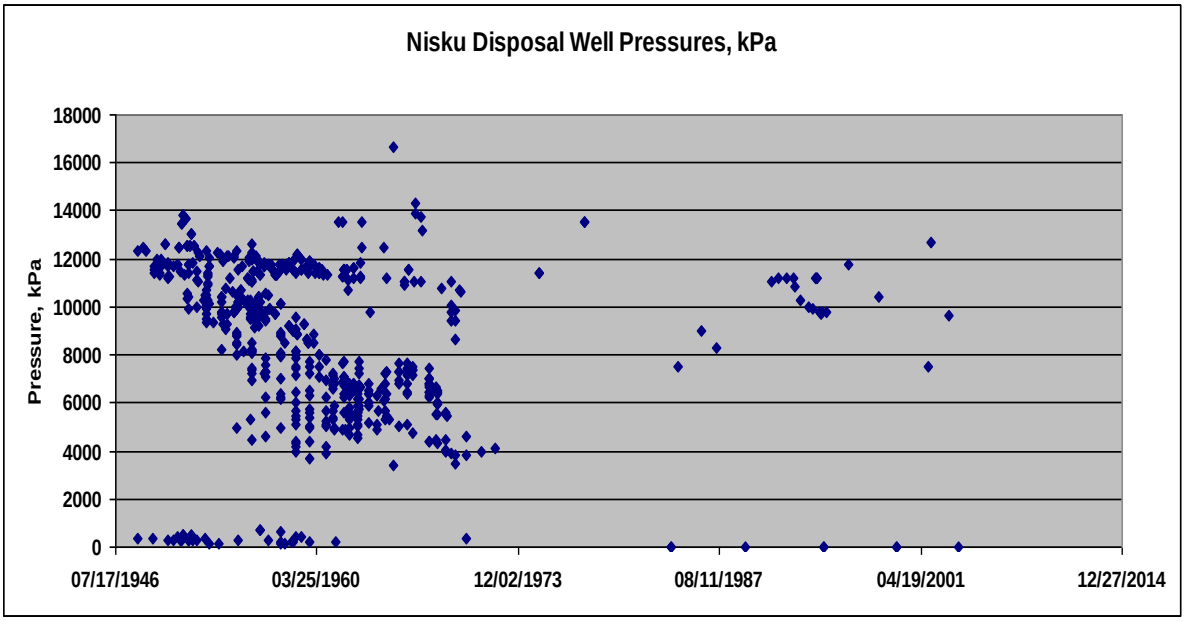


Figure 10: Pressure time history for typical water disposal wells in south west set of disposal wells.

5. CONCLUSION

Only generalized conclusions are possible from this analysis. They are:

1. Injection rates of disposal fluids into the Nisku aquifer in the analogous region to the south west of Edmonton and east of the WASP study area are only about 20% of the injection rate needed for a single commercial CO_2 injection well to store 1 Mt CO_2/year. Whether or not these are the limitations of the wells investigated or simply the limitations of available disposal rates is not clear from the work done to date.
2. Reservoir pressures were depleted at the time disposal volumes were initially injected. In some oil pools that had experienced significant depletion, reservoir pressures were restored to near original conditions. Other oil pools that have shown strong aquifer support also demonstrated that disposal volumes were not large enough to impact reservoir pressures.
3. Injection volumes to the north east of Edmonton (the Edmonton industrial areas) are substantially higher than those observed in the analogous area closer to the WASP study area.

REFERENCES

1. Personal conversation with Frank Stoakes of Stoakes Consulting Group.