

# **Airborne Laser Fluorosensor (MkIII) Survey Reprocessing And Interpretation Report: Barrow And Dampier Sub-Basins, North West Shelf**

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## Summary

The Barrow / Dampier airborne laser fluorosensor (ALF) survey was flown over the Barrow and Dampier Sub-basins (Figure 1) in May 1994 by World Geoscience Corp using the ALF MkIII system. The survey was designed to detect natural oil seepage over the region in an effort to calibrate the ALF technique over known accumulations and refine the prospectivity assessment elsewhere.

Approximately 20,000km of data was acquired in a NW-SE direction with a line spacing of 1000m. The survey area covers several oil and gas fields including the Goodwyn gas and condensate field, North Rankin gas field, Cossack and Wanaea oil fields, Legendre oil field and the Wandoo heavy-oil field.

This report is a re-interpretation of the World Geoscience data by Signalworks Pty Ltd using the *ALF Explorer™* software. A total of 3911 fluors were picked out of the 12,576,264 recorded spectra in the final interpretation of the main survey area. This is an average fluor density of 0.31 fluors per thousand spectra. Over the Goodwyn survey area, 105 fluors were picked out of the 117,558 spectra. This is an average fluor density of 0.89 fluors per thousand spectra.

Several low intensity fluor clusters could be identified on the Barrow / Dampier ALF survey. These clusters should be compared with geological interpretations to determine their cause. The wide 1km line spacing may be too wide to identify any higher intensity fluor clusters.

## 1. Introduction

The Barrow / Dampier airborne laser fluorosensor (ALF) survey was flown over the Barrow and Dampier Sub-basins (Figure 1) in May 1994 by World Geoscience Corp using the ALF MkIII system. This system uses a 266nm laser wavelength, shorter than the 308nm used in the MkII system. The Raman peak wavelength is 293nm (344nm MkII) and the fluorescence region is 320nm to 580nm (370nm to 580nm MkII).

The survey area is shaded in red on the location map (Figure 1). The Browse Basin and Barrow Sub-basin MkII ALF surveys are shaded in green (Williams, 1990a,b and Cowley, 2001a,b\*). The Barrow survey overlaps much of the Barrow / Dampier MkIII survey.

Approximately 20,000km of data was acquired in a NW-SE direction with a line spacing of 1000m (Figure 2). The sensor height was 80m.

The survey covers several oil and gas fields including the Goodwyn gas and condensate field, North Rankin gas field, Cossack and Wanaea oil fields, Legendre oil field and the Wandoo heavy-oil field.

12,576,264 spectra were acquired in the main part of the survey. Several additional lines (10010 to 10140) were flown over part of the Goodwyn field and these were separated during the initial analysis. This avoided the closer line spacing affecting the fluor patterns on the regional mapping. The 14 Goodwyn lines contain 117,558 spectra.

Because the Barrow / Dampier survey was very large, it was split into seven separate projects for interpretation using the *ALF Explorer™* software as shown in Figure 3. This figure also shows the lines that were missing during the initial interpretation phase. The results of each sub-project were merged into combined project for final analysis and display.

Gaps in the ALF survey coverage are due to lines not flown, incomplete or corrupted data. Lines 11140, 11150 and 11160 were never flown. Lines 11170 and 11180 were never completed. Lines 10560, 10720, 10830, 10961, 10990 and 11520 initially had corrupted data and could not be completely loaded.

Fugro Airborne Surveys supplied new copies of several data files and the following lines were reloaded: 10560, 10830, 10990 and 11520. A new copy of line 10961 was also supplied but this file was identical to the original one, which did not extend the full length of the survey. Fugro confirmed that line 10720 was corrupted and line 10961 was incomplete.

A total of 3911 fluors were picked out of the 12,576,264 recorded spectra in the final interpretation of the main survey area. This is an average fluor density of 0.31 fluors per thousand spectra. Over the Goodwyn survey area, 105 fluors were picked out of the 117,558 spectra. This is an average fluor density of 0.89 fluors per thousand spectra.

**Mapping Specifications:**

Projection: Southern UTM Zone 50 (Central Meridian 117 degrees east)

Projection Datum: AGD84.

The following boundaries were used for mapping:

Min easting: 350,000

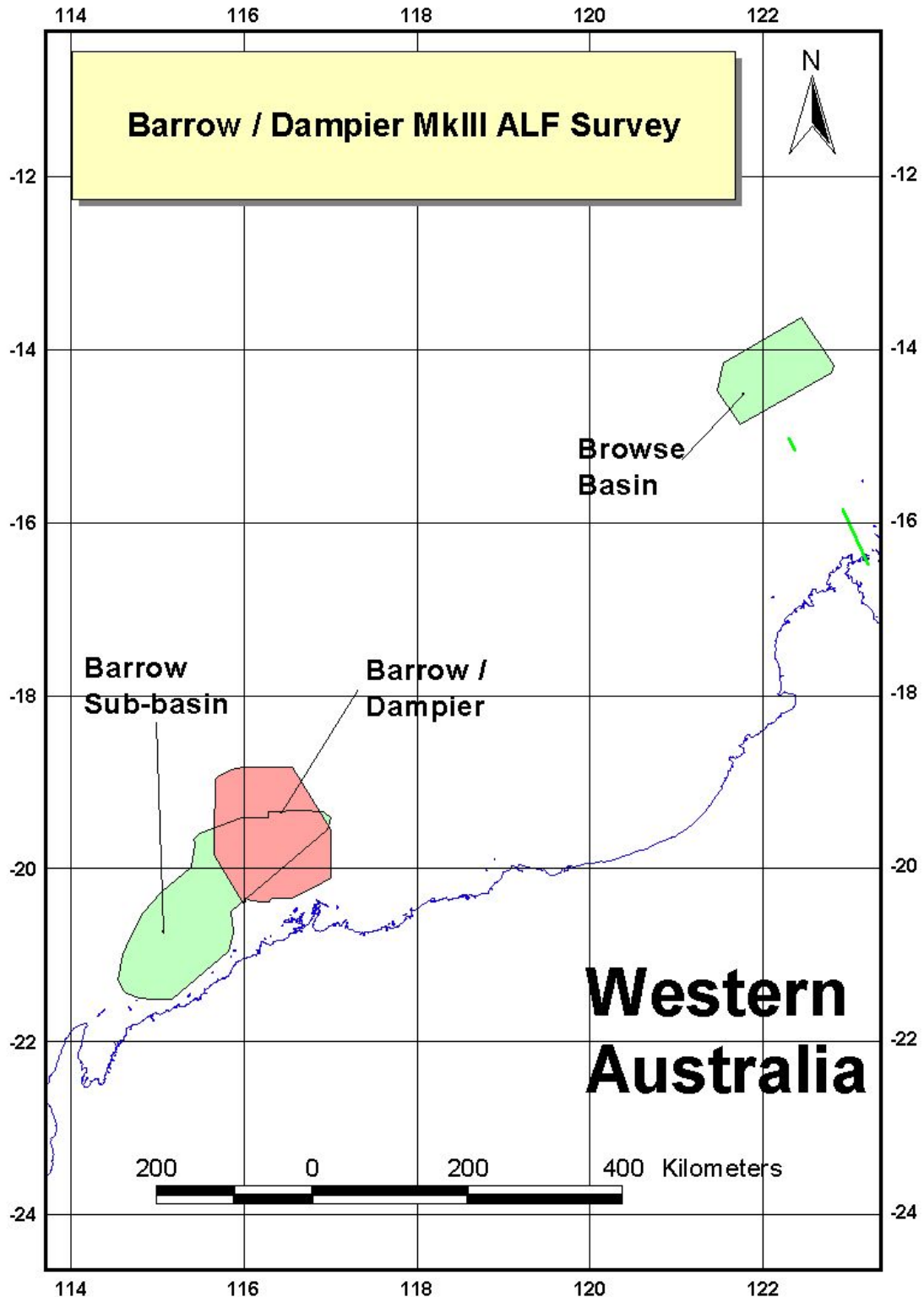
Max easting: 510,000

Min northing: 7,720,000

Max northing: 7,930,000

\* Bibliographic references:

Williams, A.K. and Mackintosh, J.M. 1990a. ALF Survey of the western margin of Australia. 4. Browse Basin. Volume 1, A – Basic Data Report; Volume 2, B – Interpretive Data Report; Volume 3, C – BP In-house Report. Remote Sensing Group, BP Exploration (unpubl. Report). Williams, A.K. and Mackintosh, J.M. 1990b. ALF Survey of the western margin of Australia. 5. Carnarvon Basin. Volume 1, A – Basic Data Report; Volume 2, B – Interpretive Data Report; Volume 3, C – BP In-house Report. Remote Sensing Group, BP Exploration (unpubl. report). Cowley, R., 2001a. MkII Airborne Laser Fluorosensor Survey Reprocessing and Interpretation Report: Browse Basin, North West Shelf, Australia. Record 2001/21, AGSOCAT 35634 Cowley, R., 2001b. MkII Airborne Laser Fluorosensor Survey Reprocessing and Interpretation Report: Barrow Sub-basin, Carnarvon Basin, North West Shelf, Australia. Record 2001/20, AGSOCAT 35738



**Figure 1. Barrow / Dampier MkIII ALF Survey Location Map.**  
 (The Barrow / Dampier survey is shaded in red.)  
 (Light green areas are MkII ALF Surveys.)



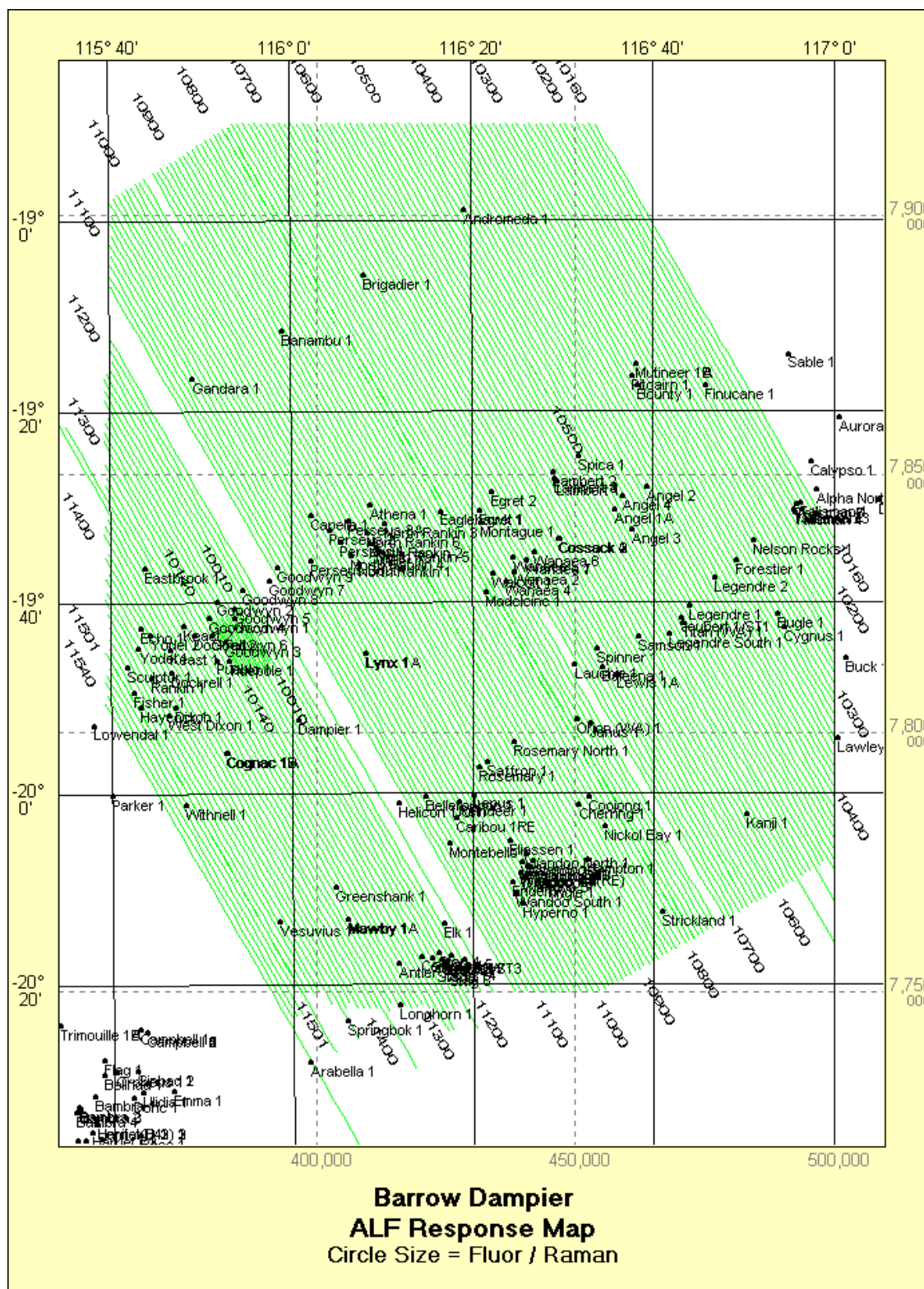


Figure 2. Barrow Dampier ALF Survey Map.

ALF Survey Reprocessing &amp; Interpretation Report: Barrow &amp; Dampier Sub-basins, NWS

## 2. ALF Survey Analysis

### 2.1. Fluor Mapping

A first pass fluorescence anomaly (fluor) interpretation produced the initial map of oil seepage shown in Figure 4. A second refined interpretation picked more low intensity fluors and provided the better definition of low intensity fluor clusters shown in Figure 6.

Fluors were picked in a two-stage process where an SQL query was used to select a number of possible fluors from which confident fluors were selected manually.

The following query was used in the first pass interpretation:

```
SELECT * FROM [RawAlfData] WHERE Ch_50 > Ch_27 / 10 ORDER BY Ch_50 DESC
```

2,275 fluors were picked out of a total of 12,576,264 spectra (181 fluors per million spectra).

Over the Goodwyn survey, 92 fluors were picked out of a total of 117, 558 spectra (782 fluors per million spectra).

The refined interpretation initially used the following query:

```
SELECT * FROM [RawAlfData] WHERE Ch_50 > Ch_27 / 20 ORDER BY Ch_50 DESC
```

Although this query picked more possible fluors, many of the high F/R ratio fluors having low recording amplitude were not picked because they do not appear near the front of the possible fluor list that is manually scanned. A further refinement using this query was used to pick the missed fluors:

```
SELECT * FROM [RawAlfData] where Ch_50 > Ch_27 / 10 order by Ch_50 desc
```

3,911 fluors were picked in the refined interpretation (311 fluors per million spectra).

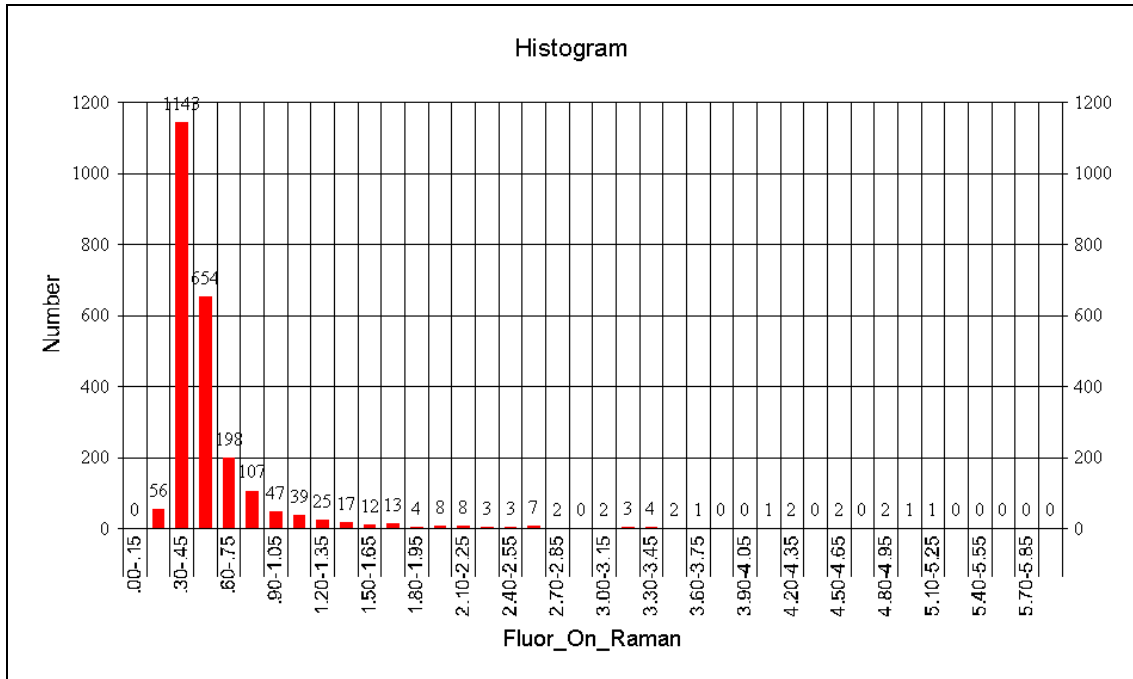
Over the Goodwyn survey, 105 fluors were picked in the refined interpretation (893 fluors per million spectra).

Fluor patterns are very similar on both fluor maps but the larger number of low intensity fluors picked on the refined interpretation provides better definition of many fluor clusters.

The data is probably affected by acquisition artifacts, causing apparent cluster trends extending along the acquisition direction.



ALF Survey Reprocessing &amp; Interpretation Report: Barrow &amp; Dampier Sub-basins, NWS



**Figure 5. First Pass Fluor on Raman Histogram.**

A histogram of the intensity of the fluors, as measured by the fluorescence / Raman area ratio, is shown in Figure 5. The fluor intensity distribution shows an exponential curve (increasing towards the lower intensities) until the curve decreases again at low intensities. The decrease is due to the difficulty in picking low intensity fluors above the noise in the data.

2367 fluors were picked in the first pass interpretation. The Raman area is calculated between 278.63nm and 308.28nm. The fluorescence area is calculated between 311.99nm and 479.70nm. The histogram is plotted between 0 and 6 along the X axis (F/R) in 40 steps.

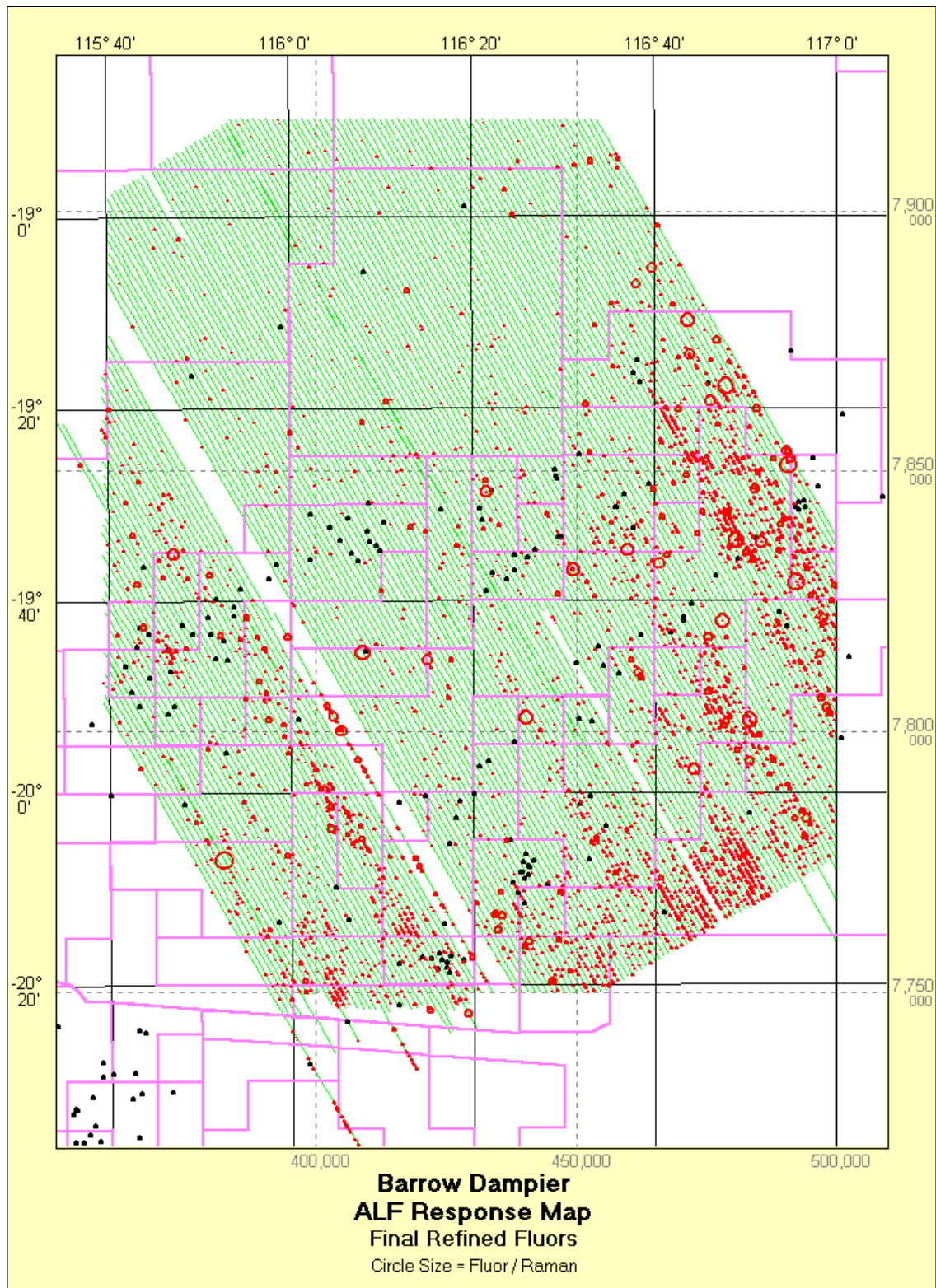


Figure 6. Final Refined Fluor Map.

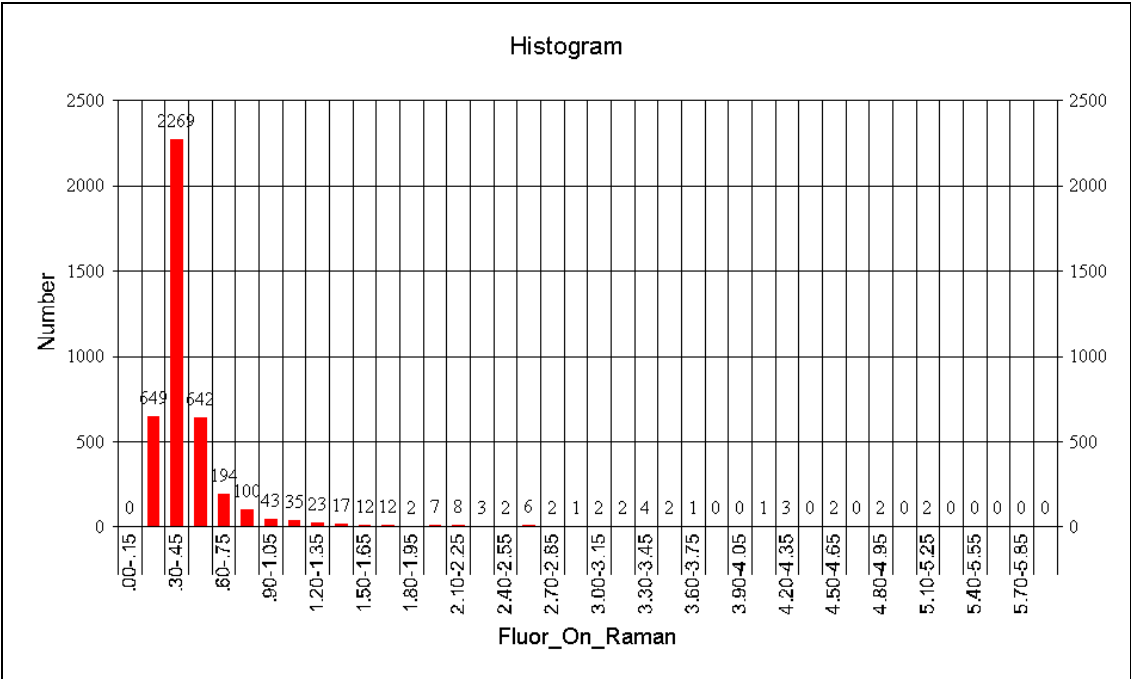
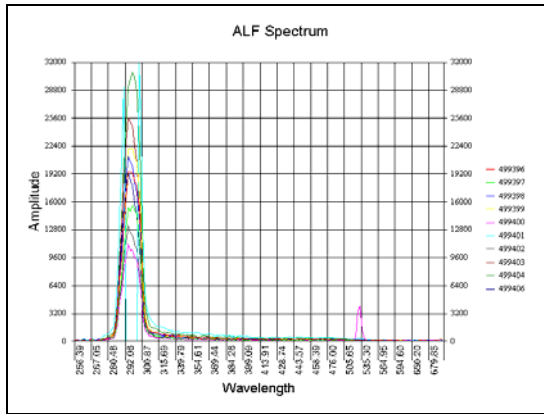


Figure 7. Final Fluor on Raman Histogram.

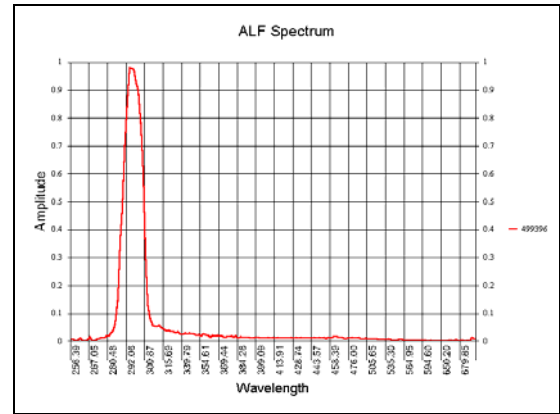
A histogram of the intensity of the fluors in the final interpretation is shown in Figure 7. The fluor intensity distribution shows an exponential curve (increasing towards the lower intensities) until the curve decreases again at low intensities.

Many more low intensity fluors were picked in the final interpretation. There are some differences in the number of higher intensity fluors between the two interpretations because they were done independently.

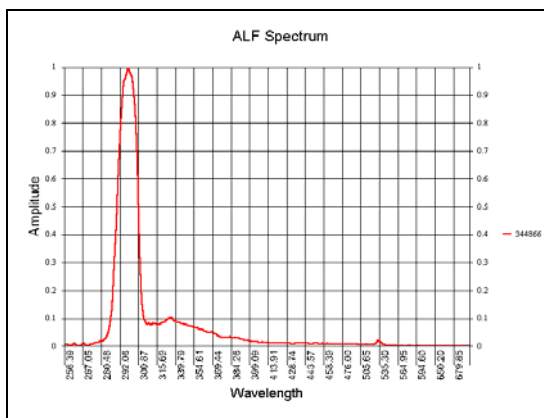
3911 fluors were picked in the final interpretation. The histogram is plotted between 0 and 6 along the X axis (F/R) in 40 steps.



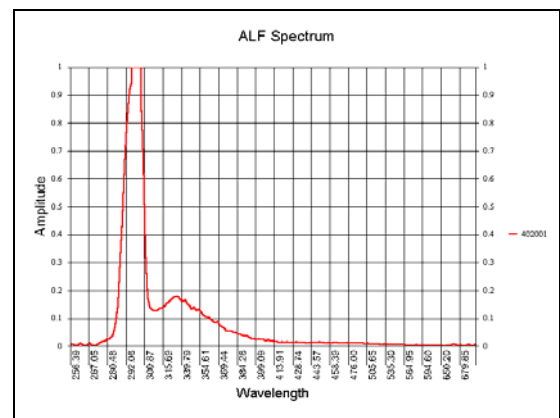
7 a) Line 10160 Ten Adjacent Fluors.



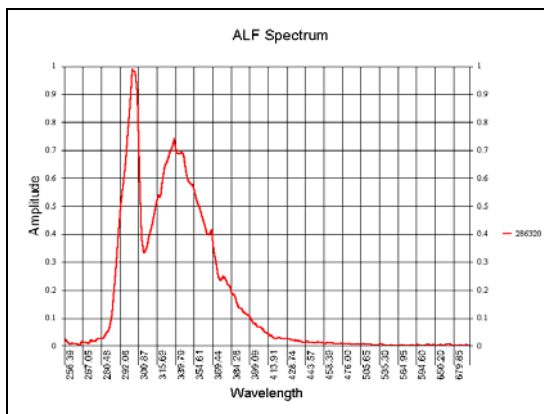
7 b) Line 10160 No Fluor.



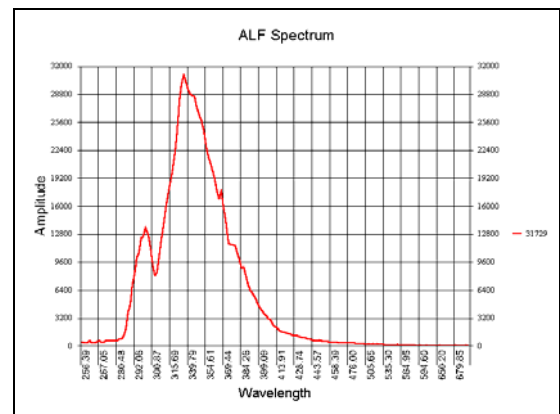
7 c) Line 10890 Small Fluor.



7 d) Line 10620 Small to Medium Fluor.



7 e) Line 11400 Medium to Large Fluor.



7 f) Line 10270 Large Fluor.

Figure 8. Barrow / Dampier ALF Survey Selected Spectra.

Figure 8 shows a selection of spectra and fluors picked on the Barrow / Dampier survey.



## **2.2. Adjacent Fluor Detection**

Most fluors detected are isolated anomalies and indicate the presence of individual oil films. The sampling resolution of ALF is one sample, which covers an area of 200mm, every 1.5m. However, the detection of adjacent fluors may indicate areas of more significant hydrocarbon seepage. Therefore, the final interpreted fluor data set was produced to identify adjacent fluors.

17 groups of two or more adjacent fluors were detected and are plotted on the map shown in Figure 9. Many of these are associated with larger intensity fluors.

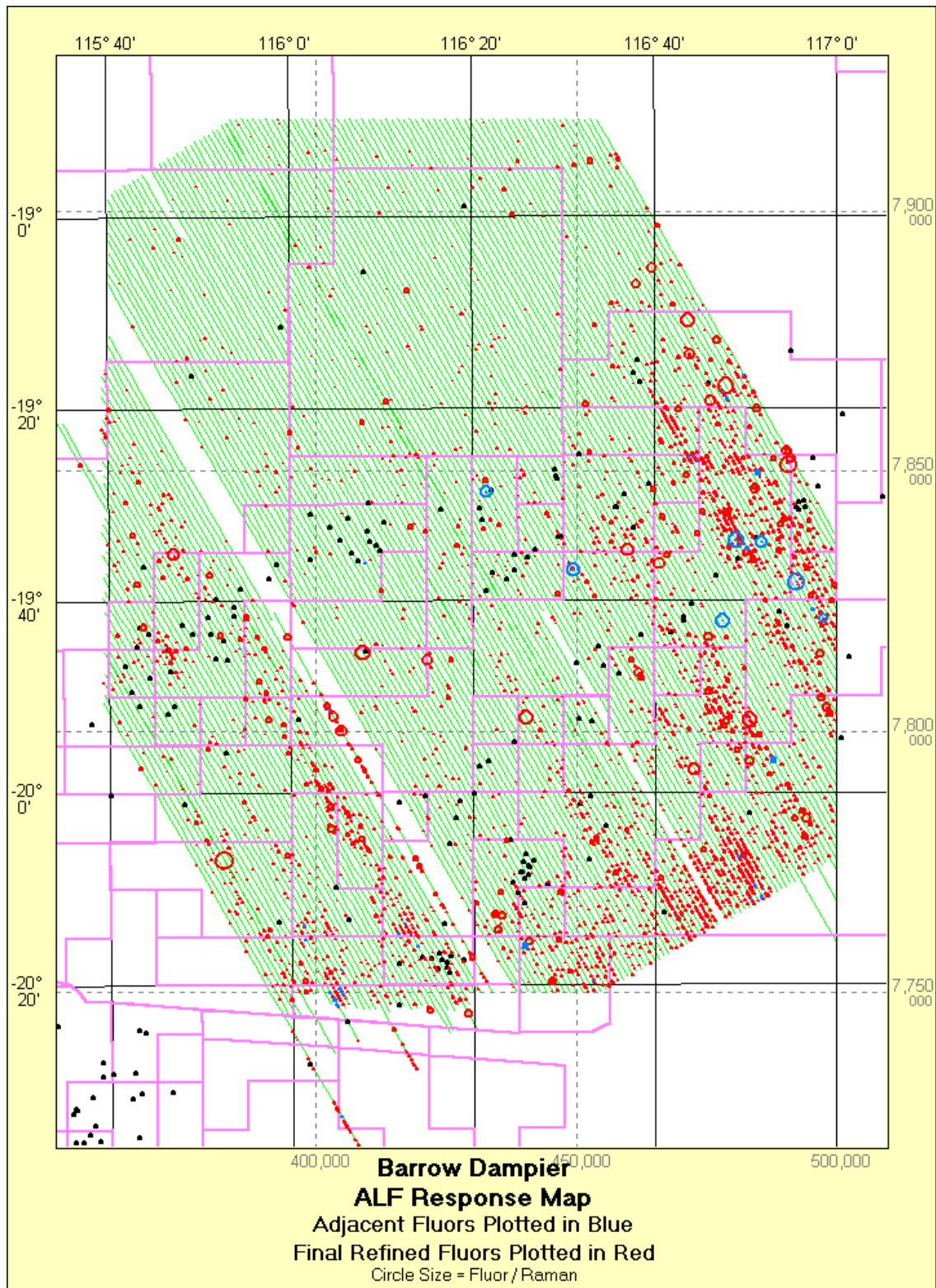


Figure 9. Map Showing Adjacent Fluors Plotted in Blue.

### **2.3. Near Fluor Detection**

Groups of near fluors from the final interpretation were also looked for to determine whether these would enhance the areas of more significant hydrocarbon seepage identified by the adjacent fluors. A gap distance of 10 fluors or about 15m was selected so that any fluors separated by less than this distance were grouped together.

122 near fluor groups were detected and are plotted on the map shown in Figure 10. The adjacent fluor groups form a subset of the near fluor groups. Most of the near fluor groups are located within larger low intensity fluor clusters.

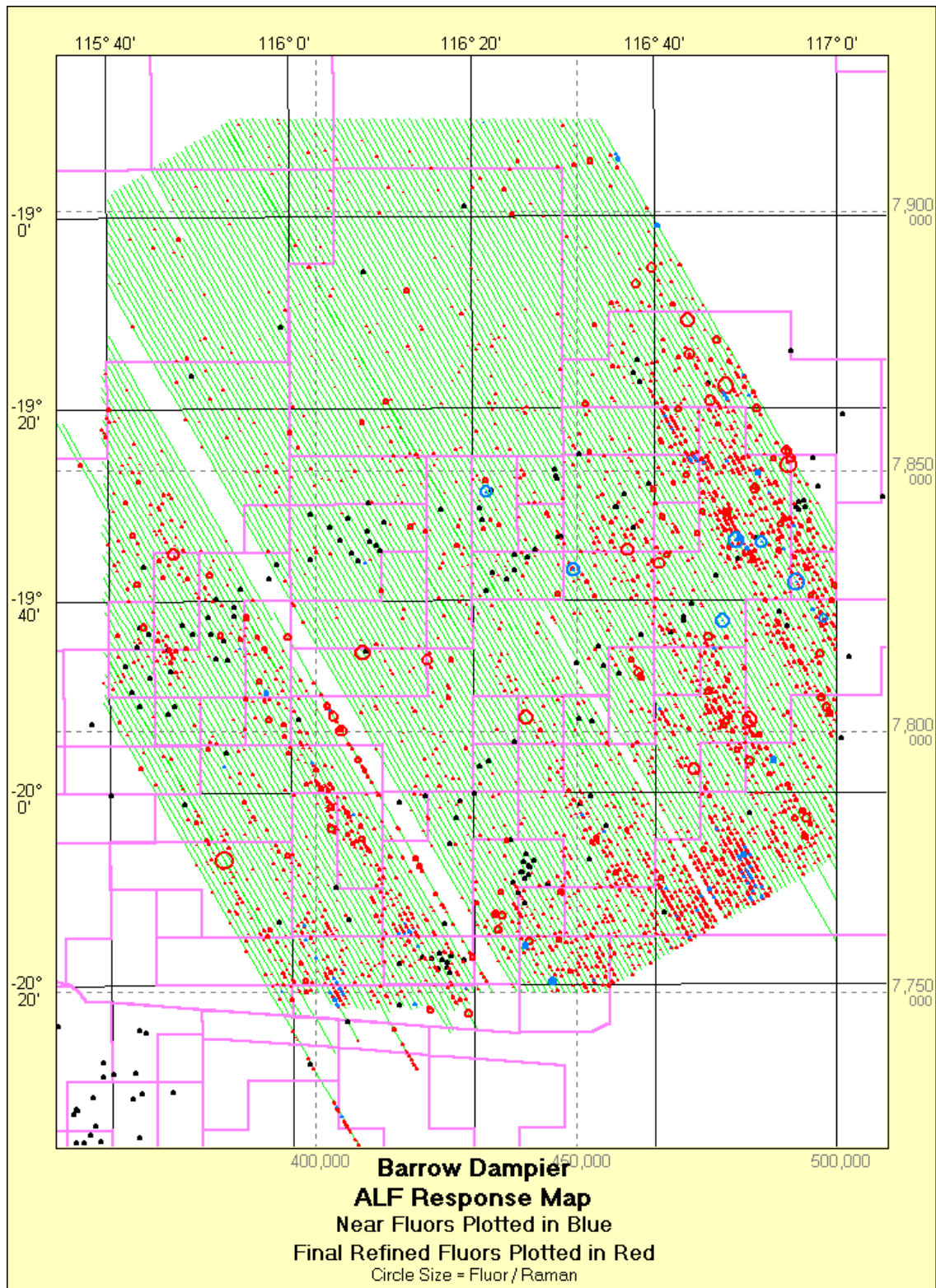
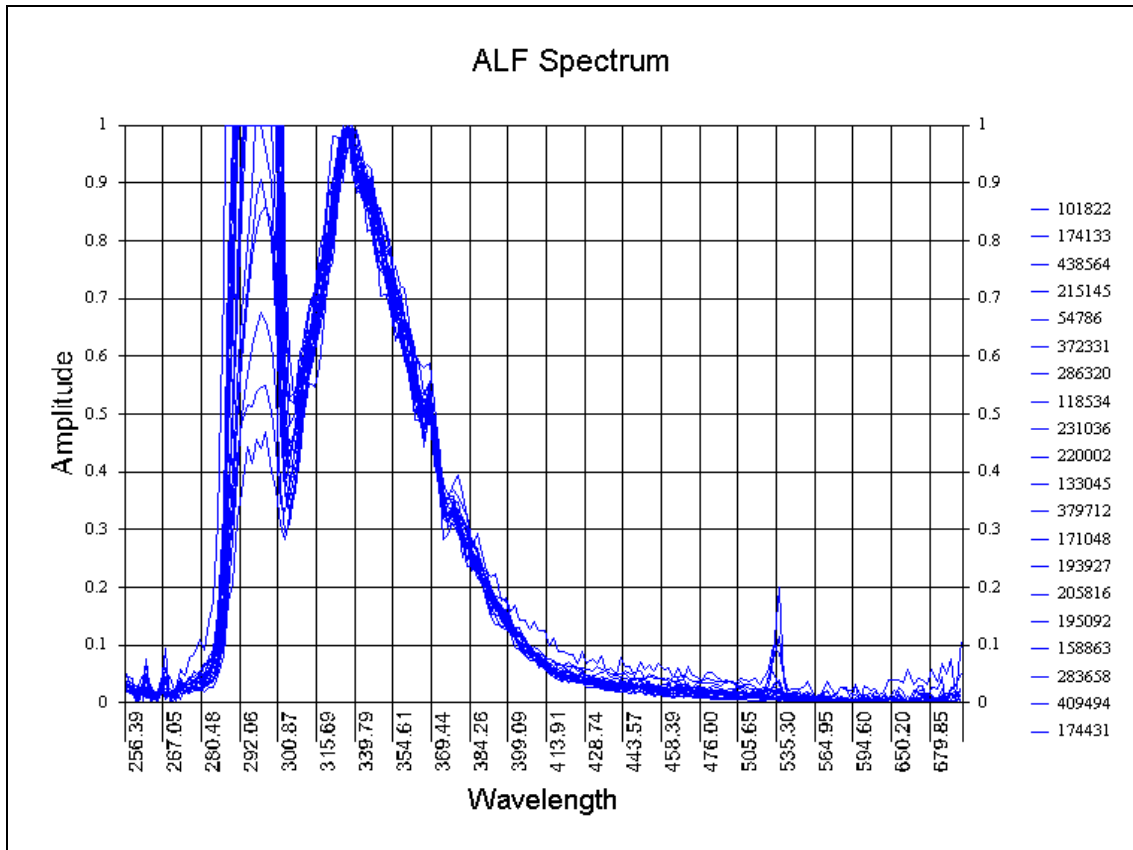


Figure 10. Map Showing Near Fluors Plotted in Blue.

## 2.4. Fluorescence Curve Trend Analysis



**Figure 11. Fluor Group 1.**

The consistency in fluor shape is notable for many fluors across this survey. Figure 11 show a collection of fluors plotted with fluor peak normalization. This set of 20 fluors, selected from all over the survey, have similar spectra.

A map of fluor peak wavelength is plotted in Figure 12. Circle size and colour vary with the peak wavelength to highlight variations. Fluors having a longer peak wavelength are plotted as a larger blue circle. A selection of these anomalous fluors is shown in Figure 13, plotted with fluor peak normalisation. This figure also shows a common fluor shape plotted in red.



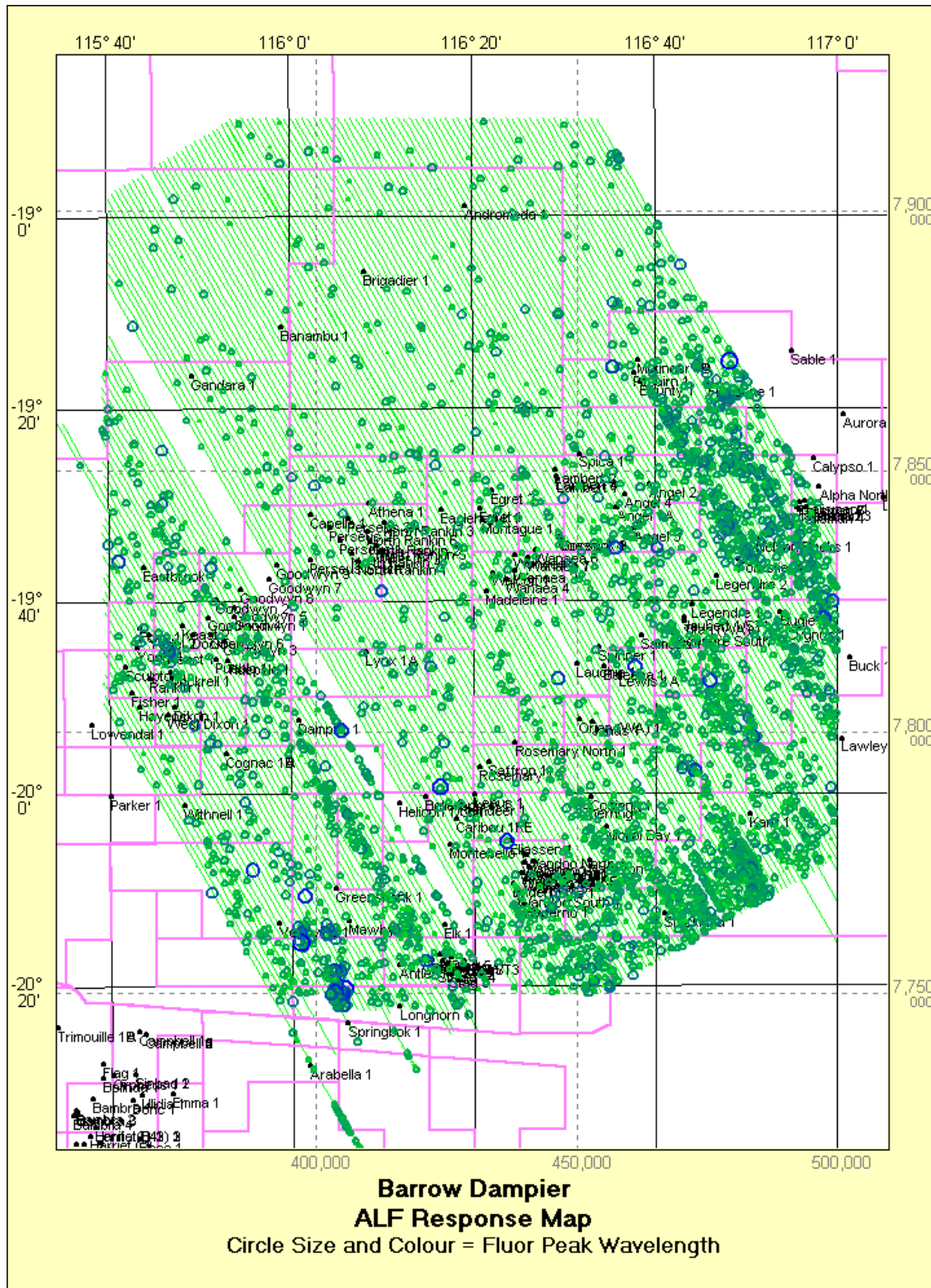


Figure 12. Fluor Peak Wavelength Map.

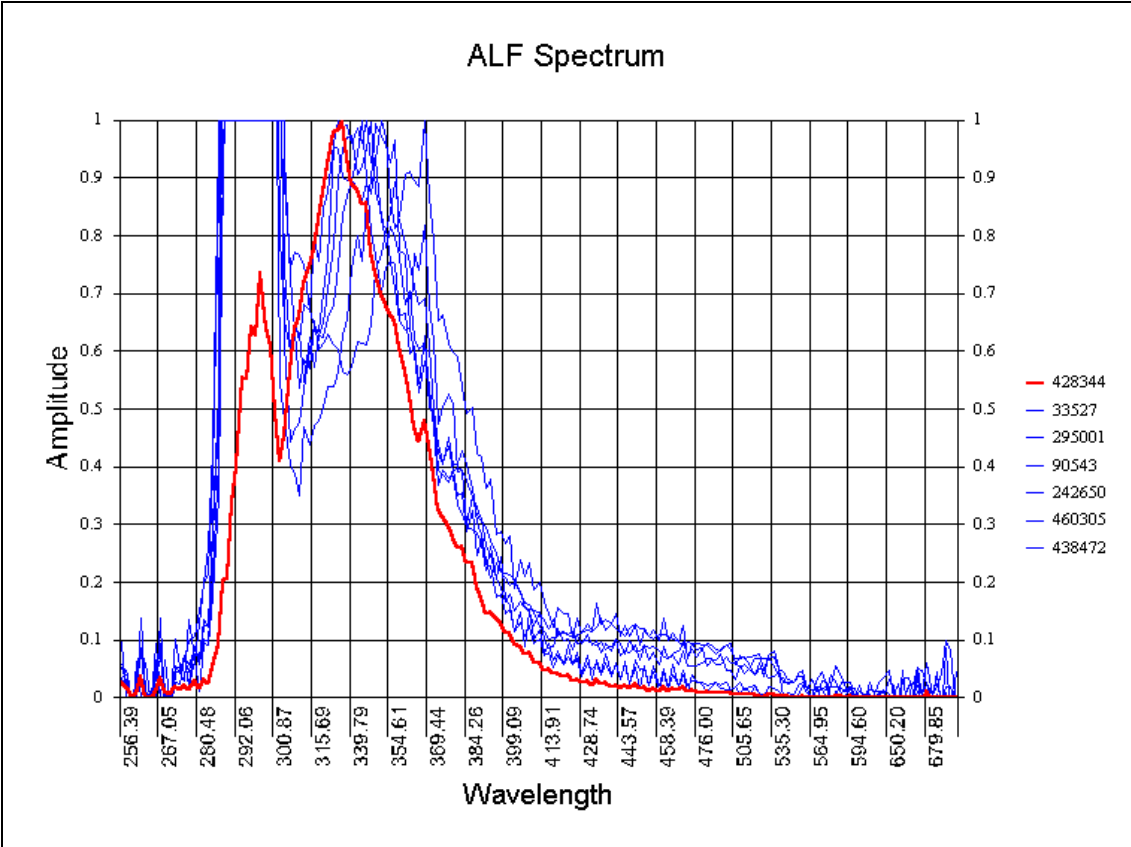


Figure 13. Long Peak Wavelength Fluors.

## 2.5. Fluor Cluster Interpretation

A map of interpreted fluor clusters is shown in Figure 14. Several small but well-defined clusters are shaded in green. Some significant clusters with more diffuse distribution are shaded in orange. Possible clusters with poor definition are shaded in yellow. The remaining fluors have a scattered distribution but with some clustering still evident.

There is no obvious correlation between fluor clusters and known accumulations. Whereas, in other surveys clusters of high intensity fluors have been associated with accumulations. High intensity fluors occur much less frequently than low intensity fluors so the clusters are difficult to detect using a 1km line spacing.

Fluor density is low in the northern part of the survey, which may indicate the presence of either a poor oil source or a good seal.



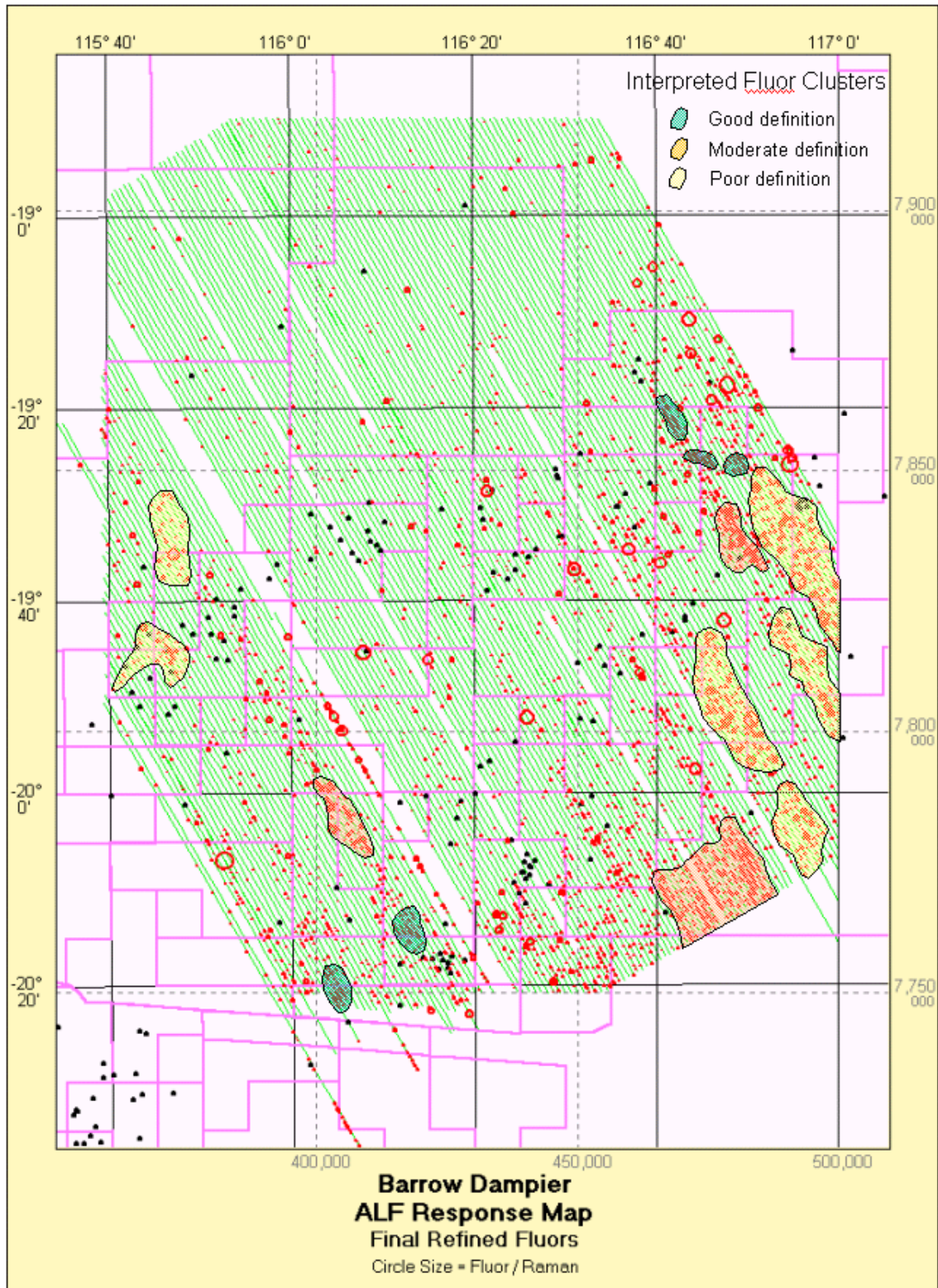


Figure 14. Interpreted Fluor Clusters.

### 3. Goodwyn Region Mapping

Fourteen extra ALF lines were flown over the Goodwyn field at a 500m spacing. These lines are shown in Figure 15.

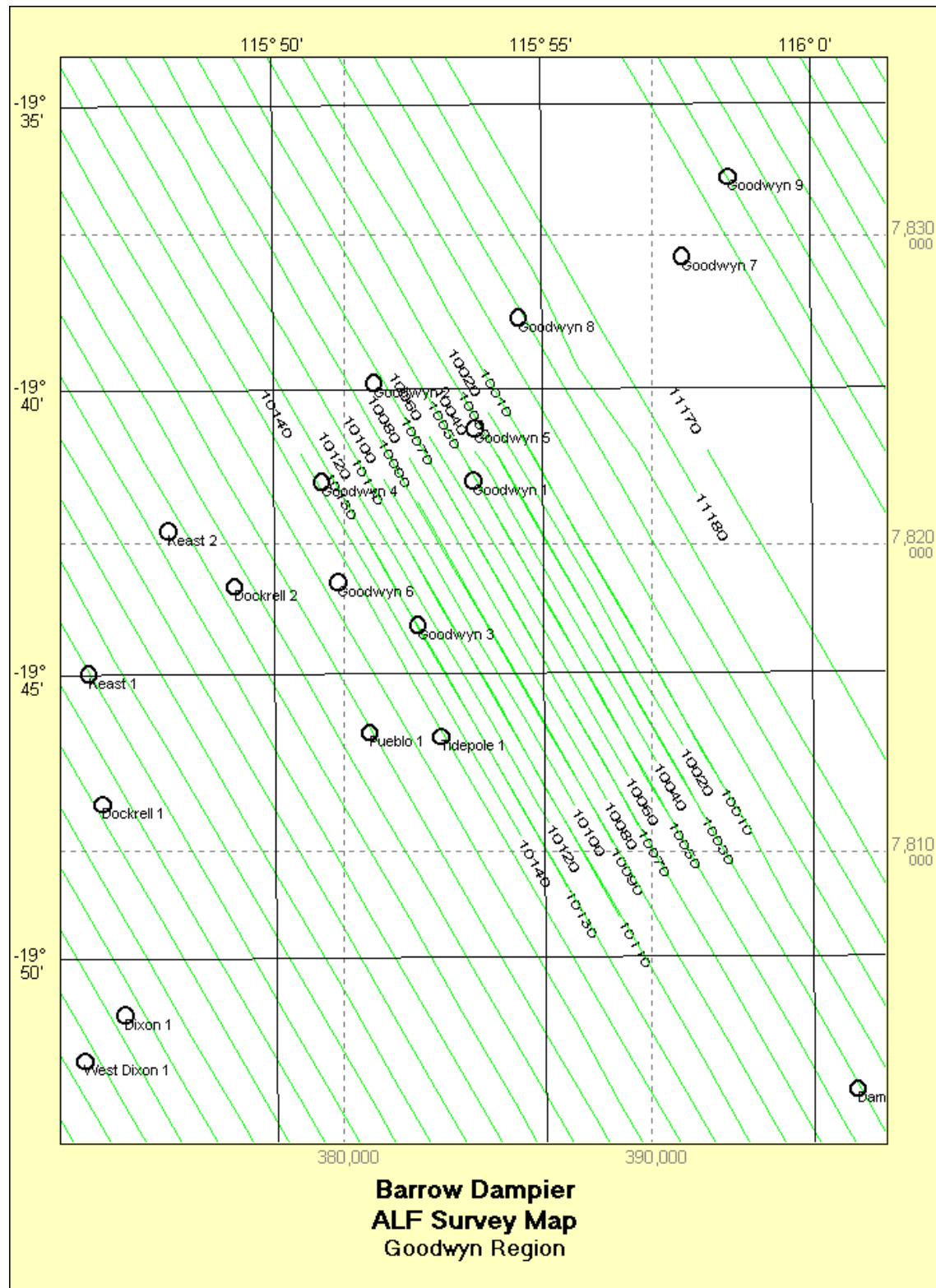
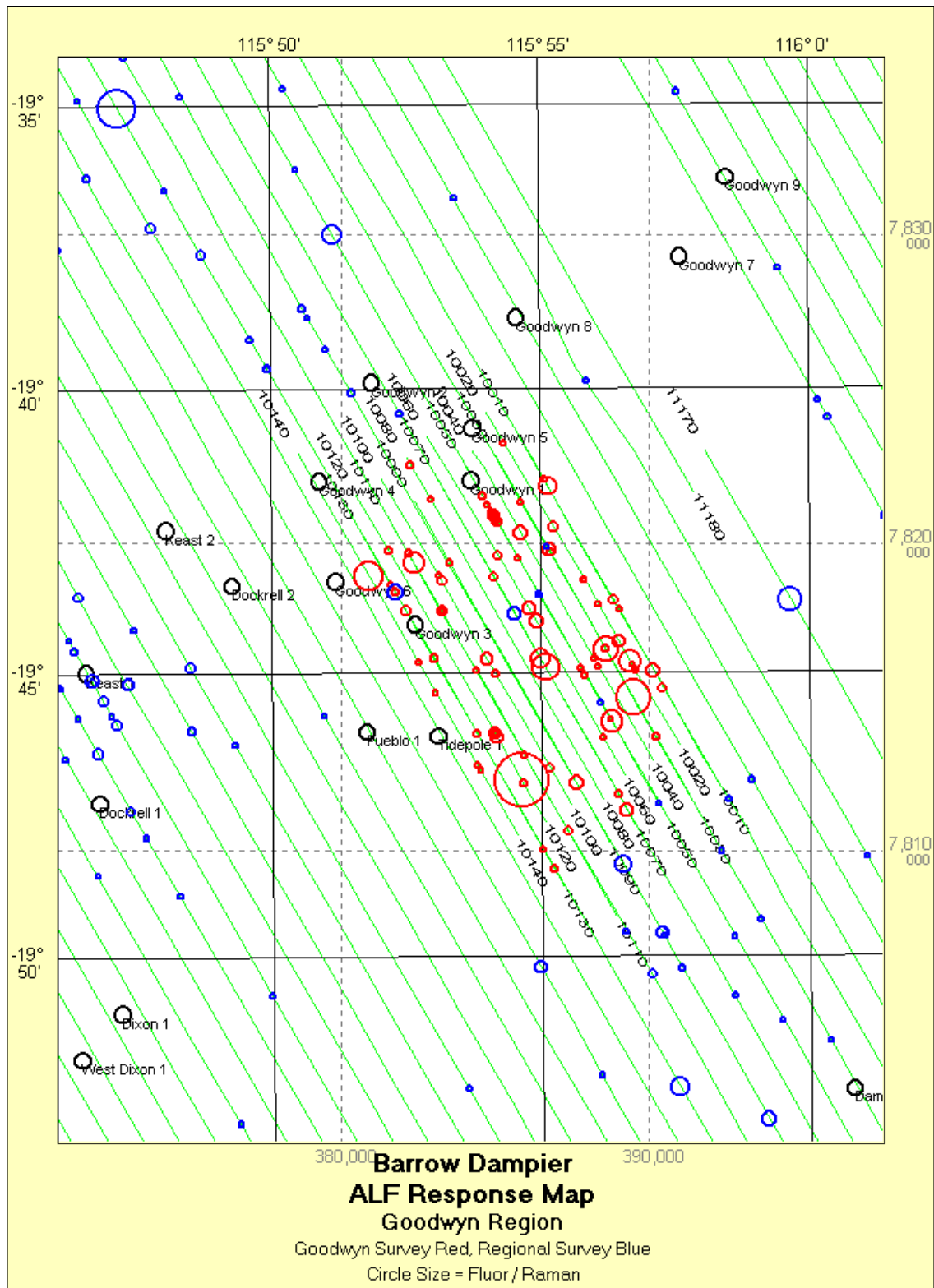


Figure 15. Goodwyn Region ALF Survey Map.



**Figure 16. First Pass Goodwyn Fluor Map.**

A first pass map of the Goodwyn survey fluors is shown in Figure 16. The Goodwyn fluors are plotted in red and the regional survey fluors are plotted in blue. The final interpretation (Figure 17) includes more low intensity fluors but the cluster patterns remain the same. A total of 105 fluors were picked out of the 117,558 spectra. This is an average fluor density of 0.89 fluors per

thousand spectra. The increased density of Goodwyn survey fluors (red) detected on the 500m spaced lines is partly caused by the closer line spacing. There may also have been more oil patches present when the survey was run. There are certainly more high intensity fluors on the Goodwyn survey. No significant changes in acquisition parameters were noted between the surveys.

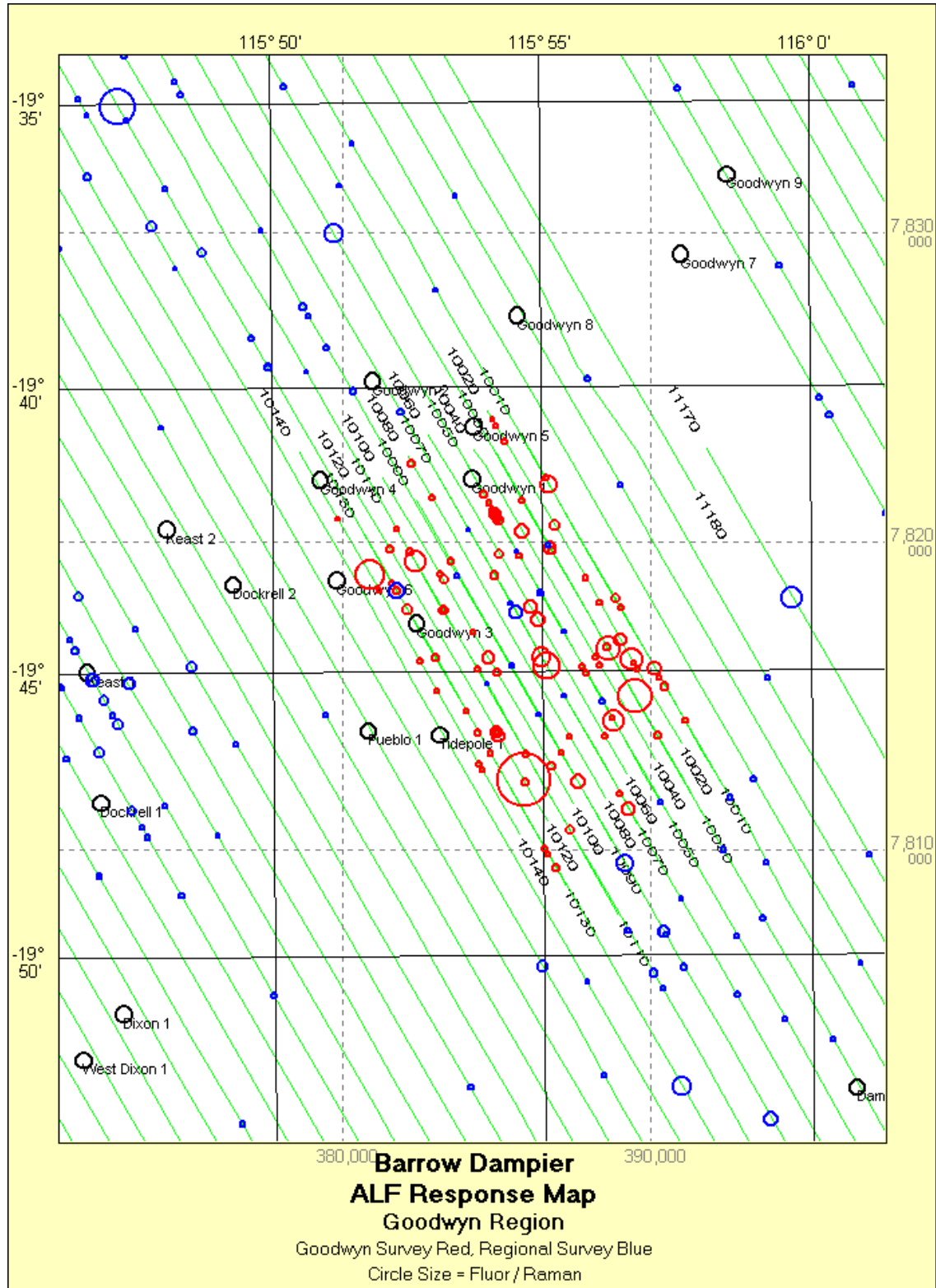


Figure 17. Final Goodwyn Fluor Map.

## **4. Conclusions and Recommendations**

Several low intensity fluor clusters could be identified on the Barrow / Dampier ALF survey. These clusters should be compared with geological interpretations to determine their cause. The wide 1km line spacing may be too wide to identify any higher intensity fluor clusters.

Fluor spectra shapes are surprisingly consistent over this survey, given the known chemical and physical variation in Carnarvon oils and condensates. Consistency in the ALF data is highlighted on the fluor peak wavelength map (Figure 12).

The Goodwyn ALF survey with a 500m line spacing detected many more fluors than the regional survey, including many of higher intensity. The Goodwyn survey does not cover a wide enough area to show if the fluor clusters are associated with accumulations.



## Appendix 1. Data Acquisition QC

Line	Sections	Clipped	Avg Raman Peak	Avg Raman Variance
10840	1196	320	14,199	15,320,140
10850	1101	475	16,155	20,356,350
10860	1225	92	12,885	11,557,430
10870	1089	228	15,042	15,521,200
10880	1460	85	12,267	8,532,627
10890	1005	242	14,982	13,622,000
10900	1274	7	10,493	5,227,585
10910	1055	86	12,962	8,900,887
10920	1227	61	13,896	11,512,160
10930	1026	264	17,281	14,517,390
10940	1237	9	11,099	6,690,553
10950	1029	97	13,734	8,952,651
10961	1063	62	12,117	10,761,630
10970	1063	23	12,257	8,743,390
10980	1180	223	14,731	11,556,590
10990	53	0	15,148	8,759,806
11000	1201	9	11,584	8,404,747
11010	1026	144	14,664	13,559,960
11020	1208	85	14,212	11,138,920
11030	1024	446	18,445	17,657,760
11040	1211	55	14,128	9,988,979
11050	1013	3	11,309	5,823,969
11060	1148	0	10,652	5,817,950
11070	1012	12	13,228	8,859,376
11080	1175	427	15,877	19,724,790
11090	970	270	13,273	19,747,370
11100	1163	193	13,708	14,114,710
11110	937	195	13,188	18,019,410
11120	1153	63	11,821	10,225,510
11130	915	283	14,991	18,610,920
11180	430	92	14,833	14,187,410
11190	839	359	15,501	21,813,440
11200	969	43	9,431	6,073,649
11210	815	134	11,991	12,844,070
11220	1009	107	12,324	9,975,164
11230	835	433	16,653	21,760,600
11240	878	501	15,063	28,434,830
11250	815	576	16,766	31,543,100
11260	847	519	16,385	28,288,350
11270	815	511	17,807	26,462,520
11280	867	305	14,531	21,246,250
11290	763	711	23,749	31,832,220
11300	796	435	16,601	27,904,020
11310	707	222	11,371	23,411,710

**Table 1a. Barrow / Dampier ALF Survey Data Acquisition Summary.**

Line	Sections	Clipped	Avg Raman Peak	Avg Raman Variance
11320	781	695	22,801	32,343,680
11330	679	534	19,279	37,198,660
11340	859	262	13,996	19,352,950
11350	801	486	15,507	33,714,160
11360	728	265	11,909	26,388,870
11370	720	649	21,970	38,259,590
11380	632	424	12,811	48,387,320
11390	637	459	12,414	52,942,180
11400	599	428	12,399	49,624,140
11410	614	439	11,138	49,760,600
11420	561	450	13,371	54,010,050
11430	594	370	10,332	42,065,390
11440	583	548	15,841	57,317,900
11450	582	164	11,539	20,755,280
11461	476	236	18,838	18,616,770
11471	552	1	11,215	5,547,915
11481	451	10	12,633	9,090,490
11490	588	85	-1,938	162,261,900
11491	522	41	14,103	9,384,614
11501	422	62	15,522	13,177,150
11510	507	28	9,151	8,294,538
11520	39	0	4,465	1,879,466
11530	483	0	8,754	5,698,009
11540	582	20	10,155	8,758,097
10690	1035	512	20,077	17,571,370
10700	1245	426	18,661	14,947,450
10710	1043	261	16,550	14,371,710
10720	731	183	16,774	13,070,590
10730	1091	320	17,145	14,768,300
10740	1203	266	15,998	12,102,770
10750	1102	312	17,303	14,122,710
10760	1211	277	16,755	13,491,550
10770	1078	286	17,422	14,964,100
10780	1216	261	16,528	13,286,900
10781	1229	77	14,846	10,288,260
10790	1091	494	18,473	19,169,000
10791	1073	136	14,369	11,570,550
10800	1310	139	13,927	11,375,640
10810	1043	536	19,009	17,914,970
10820	1293	58	13,025	8,397,005
10830	678	56	14,247	10,366,980
10520	1088	322	16,760	14,449,940
10530	1022	373	18,007	16,237,920
10540	1108	239	16,726	12,920,750

**Table 1b. Barrow / Dampier ALF Survey Data Acquisition Summary.**

Line	Sections	Clipped	Avg Raman Peak	Avg Raman Variance
10550	1028	438	18,914	16,572,030
10560	363	64	16,976	12,405,280
10570	977	496	20,185	16,531,580
10580	1211	219	17,456	11,629,900
10590	986	429	19,662	14,537,670
10600	1228	61	15,346	10,643,060
10610	1005	180	16,346	11,446,130
10620	1138	433	18,327	15,177,770
10630	1056	551	19,535	17,688,520
10640	1165	494	19,166	14,615,660
10650	1059	503	19,502	17,401,180
10660	1171	615	20,286	16,062,260
10661	82	28	18,249	13,876,420
10670	1028	488	19,197	17,896,840
10680	1221	360	18,085	14,100,130
10320	873	233	15,143	17,841,120
10330	798	292	15,433	19,025,500
10340	889	576	20,022	20,299,260
10350	829	519	19,768	20,365,970
10360	921	250	16,197	14,985,280
10370	856	383	18,139	18,394,880
10380	998	248	17,362	14,214,590
10390	848	520	20,844	19,188,610
10400	1048	236	17,373	12,496,650
10410	875	396	19,681	16,078,800
10420	1084	183	17,393	12,443,590
10430	917	214	17,431	13,398,710
10440	1096	299	18,047	13,401,710
10450	940	543	20,339	17,529,410
10460	1147	168	15,569	9,853,799
10470	964	225	17,244	13,487,310
10480	1068	476	16,076	21,109,720
10490	1023	452	15,924	21,447,880
10500	413	291	18,291	111,270,900
10501	725	239	15,777	18,019,670
10510	1032	582	19,356	19,521,770
10010	85	59	17,837	29,662,410
10020	79	45	15,904	27,790,100
10030	87	70	18,103	34,038,200
10040	74	57	17,775	34,055,370
10050	85	68	18,027	37,659,980
10060	79	64	17,807	36,658,010
10070	83	68	16,682	38,327,950
10080	80	44	16,721	24,956,430

**Table 1c. Barrow / Dampier ALF Survey Data Acquisition Summary.**



Line	Sections	Clipped	Avg Raman Peak	Avg Raman Variance
10090	83	59	16,620	33,011,180
10100	78	73	18,124	43,412,740
10110	96	77	18,160	37,445,560
10120	77	58	19,715	32,948,950
10130	85	66	17,270	33,530,240
10140	89	80	20,423	38,305,880
10160	591	488	16,176	37,917,620
10170	593	497	16,957	39,663,100
10180	624	422	13,973	32,128,980
10190	623	568	18,768	42,584,060
10200	662	458	14,811	34,248,450
10210	651	584	18,769	41,266,980
10220	692	603	17,697	37,837,530
10230	684	220	11,941	20,067,830
10240	718	546	19,713	27,901,080
10250	705	445	18,210	24,775,610
10260	760	323	16,525	20,188,060
10270	734	518	19,342	24,213,450
10280	799	201	14,956	18,375,000
10290	740	348	17,076	21,334,000
10300	833	309	15,675	21,234,950
10310	769	465	18,197	23,740,410
11170	526	440	16,768	38,811,730

**Table 1d. Barrow / Dampier ALF Survey Data Acquisition Summary.**

The survey data quality was mostly good but some lines had noisy sections. The following lines were excluded for some of the interpretation stages: 10880, 10890, 10900, 10910, 11490.

The acquisition power, as measured by the averaged Raman peak of the recorded spectra, is shown in Figure 18. The power variations may be caused by laser power and recording gain variations as well as sea conditions.

The picked fluors are plotted over the ALF power map in Figure 19. Power variations do not appear to have affected the fluor patterns.

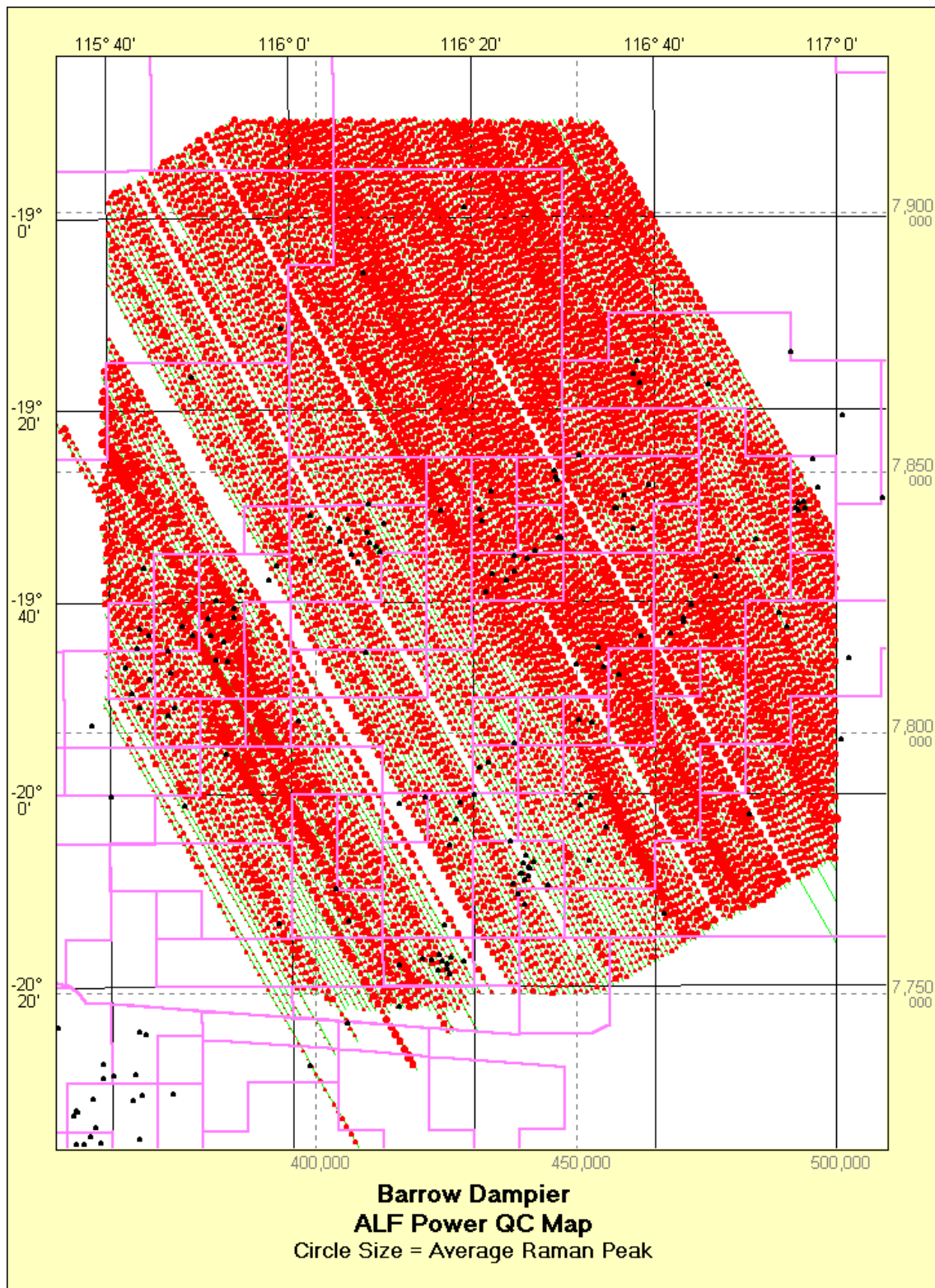


Figure 18. ALF Power Map.

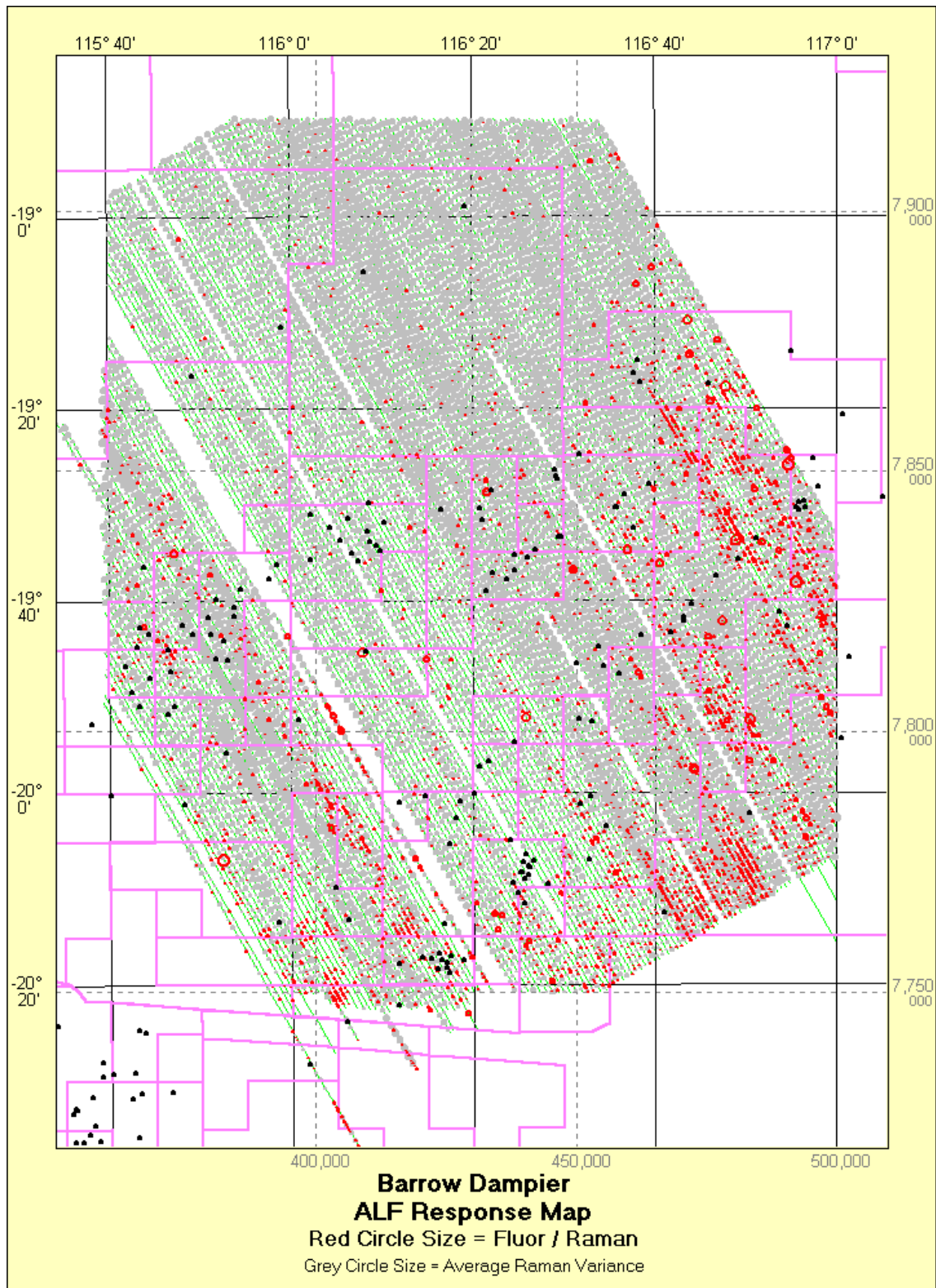


Figure 19. Fluors and ALF Power.



The Raman variance map is shown in Figure 20. This map highlights two lines, 10500 and 11490, with noisy data zones.

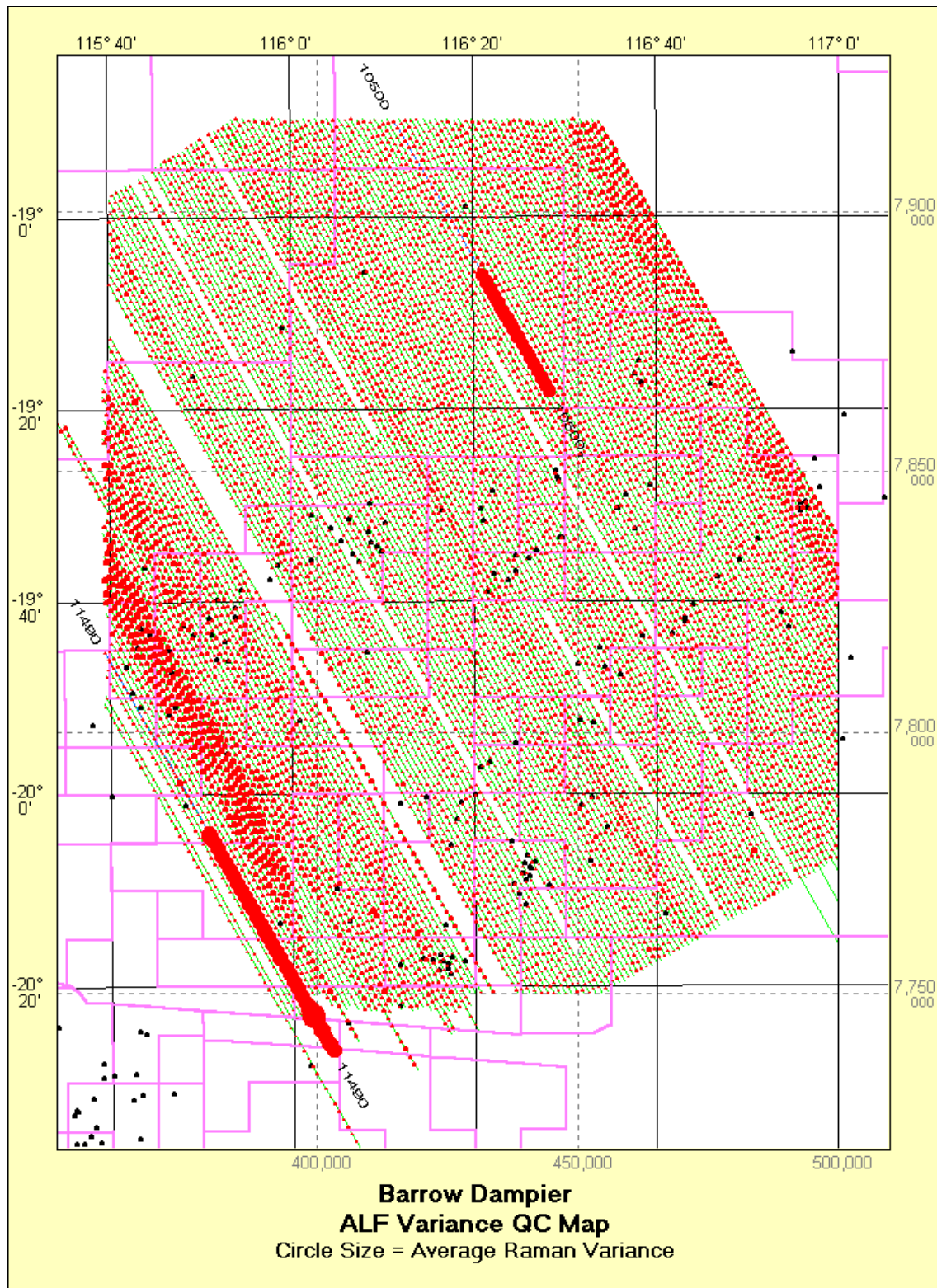
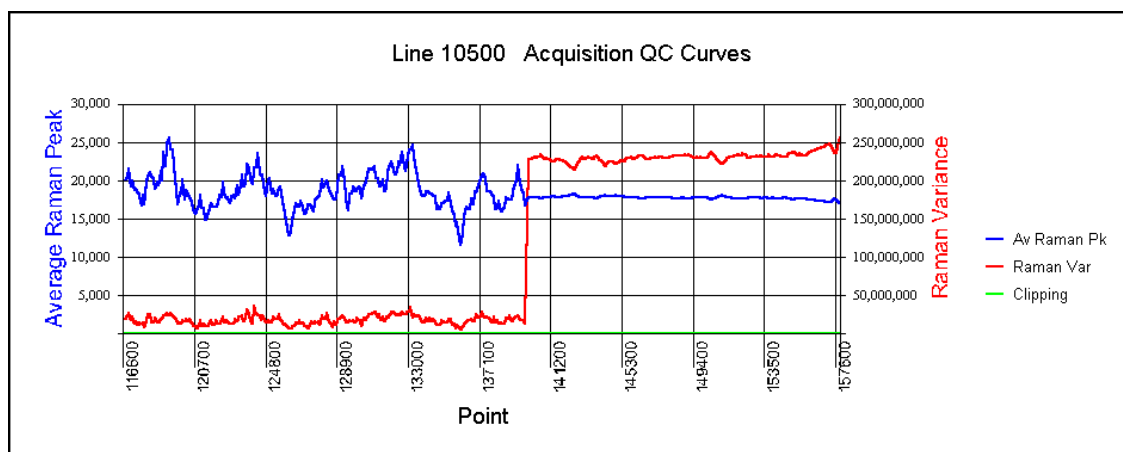
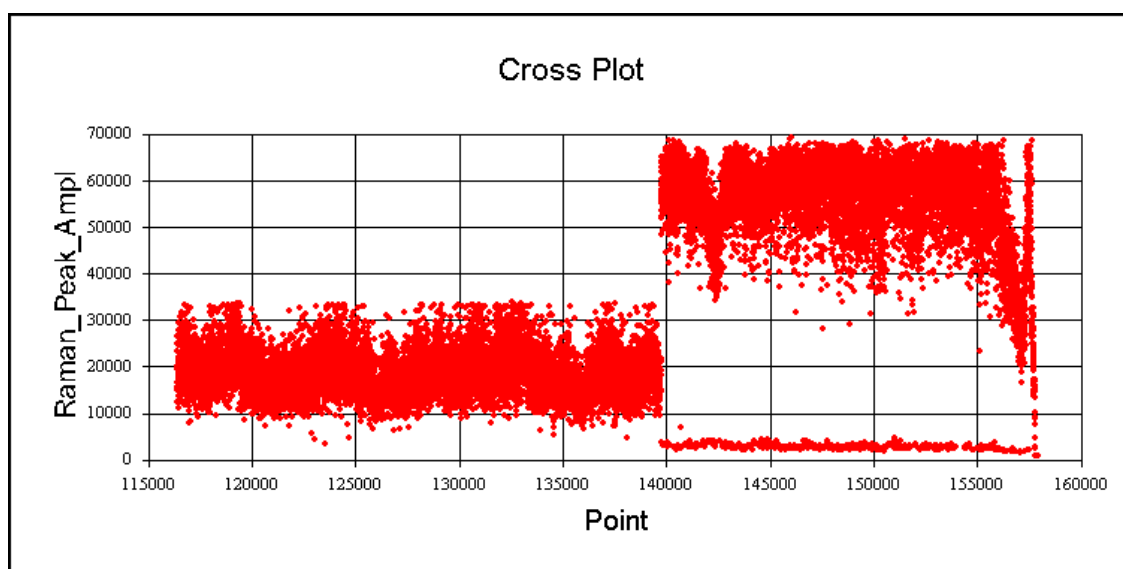


Figure 20. ALF Variance Map.



**Figure 21. Line 10500 Acquisition QC Curves.**



**Figure 22 Line 10500 Raman Peak**

The acquisition QC curves for line 10500 is shown in Figure 21. This line has very high Raman variance from around point 140,000 to the end of the line.

The Raman peak plot shown in Figure 22 is produced using decimated points (by a factor of 2) for plotting.

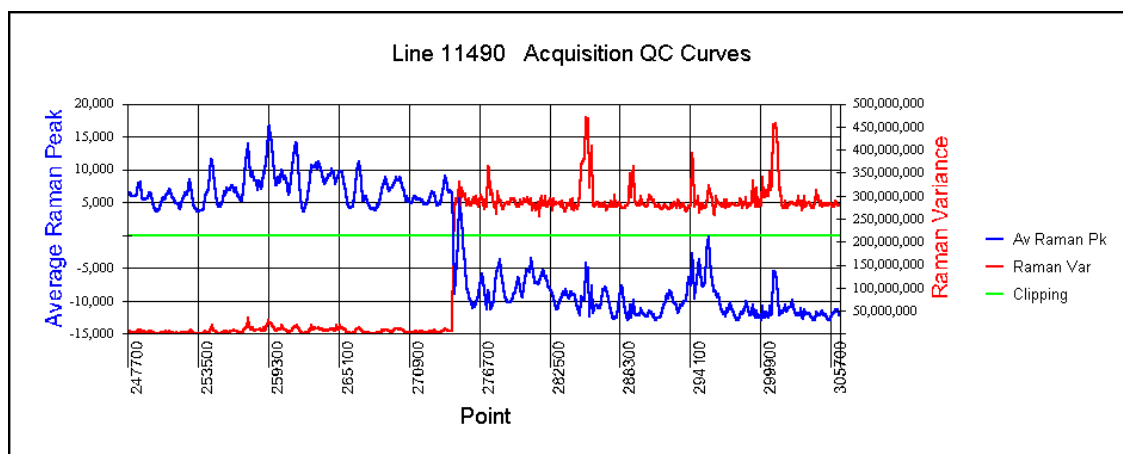


Figure 23. Line 11490 Acquisition QC Curves.

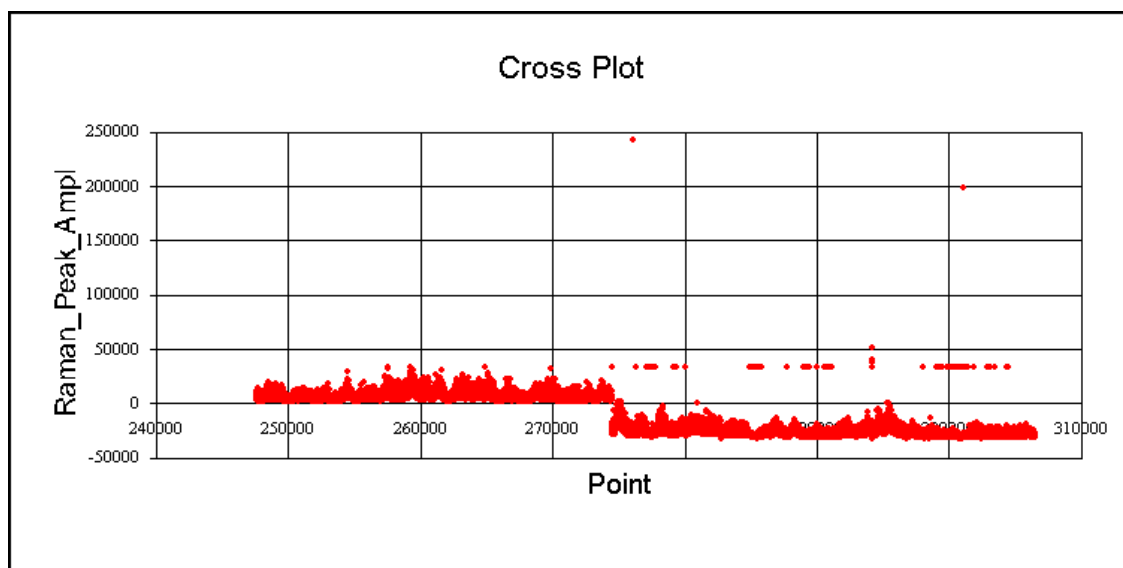


Figure 24. Line 11490 Raman Peak

The acquisition QC curves for line 11490 is shown in Figure 23. This line has very high Raman variance from around point 273,000 to the end of the line.

The Raman peak plotted in Figure 24 uses points decimated by 2 that are odd. It is only the odd numbered points that show the negative Raman peak values.

## Appendix 2. Data Navigation QC

Line	Heading (Deg)	Straight Line Distance (m)	Acquisition Time (seconds)	Avg Straight Line Velocity (km/hr)	Points	Flight Distance (m)	Avg Flying Velocity	Avg Point Spacing (m)
10010	330.13	13,195.62	169.48	280.30	8,643	13,198.39	280.36	1.53
10020	149.74	12,533.58	156.99	287.42	8,006	12,536.56	287.48	1.57
10030	330.18	13,385.18	171.97	280.21	8,770	13,387.23	280.25	1.53
10040	149.65	11,685.34	146.97	286.23	7,495	11,695.54	286.48	1.56
10050	330.12	13,222.78	168.48	282.54	8,592	13,225.20	282.60	1.54
10060	149.60	12,753.02	157.99	290.60	8,056	12,755.96	290.66	1.58
10070	330.18	12,942.27	164.99	282.40	8,413	12,945.08	282.46	1.54
10080	149.96	12,814.37	159.97	288.37	8,158	12,816.40	288.42	1.57
10090	330.17	12,751.66	164.48	279.10	8,388	12,752.95	279.13	1.52
10100	149.74	12,292.65	153.99	287.38	7,853	12,295.71	287.45	1.57
10110	330.06	14,859.04	190.99	280.08	9,740	14,860.02	280.10	1.53
10120	149.81	12,300.74	152.97	289.49	7,801	12,302.60	289.53	1.58
10130	330.09	13,173.52	168.48	281.48	8,592	13,174.06	281.50	1.53
10140	150.07	14,312.72	177.48	290.32	9,051	14,313.87	290.34	1.58
10160	150.01	92,613.97	1,159.66	287.51	59,137	92,629.84	287.56	1.57
10170	330.01	94,947.16	1,165.21	293.34	59,420	94,972.34	293.42	1.60
10180	149.98	97,188.79	1,226.44	285.28	62,542	97,202.29	285.32	1.55
10190	330.01	99,576.79	1,223.62	292.96	62,398	99,592.09	293.01	1.60
10200	150.00	101,899.30	1,299.20	282.36	66,251	101,919.90	282.41	1.54
10210	330.00	104,169.40	1,279.08	293.19	65,226	104,180.40	293.22	1.60
10220	149.99	106,478.40	1,358.90	282.08	69,286	106,489.30	282.11	1.54
10230	330.00	108,799.70	1,343.79	291.47	68,494	108,811.60	291.50	1.59
10240	150.00	110,396.70	1,409.43	281.98	71,885	110,409.70	282.01	1.54
10250	330.01	113,437.20	1,384.59	294.94	70,618	113,449.30	294.97	1.61
10260	150.00	115,728.00	1,491.68	279.30	76,079	115,745.70	279.34	1.52
10270	330.00	118,026.60	1,441.80	294.70	73,531	118,037.40	294.72	1.61
10280	150.00	120,347.80	1,567.66	276.37	79,955	120,370.50	276.42	1.51
10290	330.00	122,677.90	1,453.95	303.75	74,157	122,691.30	303.79	1.65
10300	149.98	124,925.90	1,635.79	274.93	83,432	124,939.40	274.96	1.50
10310	330.00	127,304.80	1,510.29	303.45	77,028	127,317.80	303.48	1.65
10320	149.97	129,585.40	1,713.78	272.21	87,399	129,600.70	272.24	1.48
10330	330.01	131,917.70	1,567.64	302.94	79,911	131,930.30	302.97	1.65
10340	149.99	134,182.70	1,744.38	276.92	89,009	134,203.30	276.96	1.51
10350	330.05	136,707.90	1,626.12	302.65	82,970	136,734.70	302.71	1.65
10360	150.00	138,773.40	1,806.85	276.49	92,196	138,819.00	276.59	1.51
10370	330.00	141,113.30	1,680.98	302.21	85,765	141,130.80	302.25	1.65
10380	150.01	143,515.90	1,958.11	263.86	99,919	143,549.70	263.92	1.44
10390	329.99	145,709.00	1,663.17	315.39	84,869	145,728.80	315.44	1.72
10400	149.99	148,007.60	2,054.84	259.30	104,853	148,039.00	259.36	1.41
10410	329.99	150,358.10	1,716.49	315.35	87,587	150,370.50	315.37	1.72
10420	149.99	152,661.10	2,127.17	258.36	108,529	152,683.30	258.40	1.41

**Table 2a. Barrow / Dampier ALF Survey Line Navigation Summary.**

Line	Heading (Deg)	Straight Line	Acquisition Time	Avg Straight Line Velocity	Points	Flight Distance	Avg Flying	Avg Point Spacing
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		Distance (m)	(seconds)	(km/hr)		(m)	Velocity	(m)
10430	330.00	155,017.20	1,798.71	310.26	91,727	155,026.20	310.27	1.69
10440	149.99	157,312.40	2,149.07	263.52	109,693	157,336.30	263.56	1.43
10450	330.01	159,622.80	1,842.69	311.85	94,051	159,632.20	311.87	1.70
10460	150.00	161,954.10	2,249.42	259.19	114,794	161,971.80	259.22	1.41
10470	330.00	164,190.90	1,892.82	312.28	96,600	164,201.50	312.30	1.70
10480	149.99	166,523.20	2,115.04	283.44	108,126	166,537.30	283.46	1.54
10490	330.01	165,044.70	2,002.14	296.76	102,352	165,055.90	296.78	1.61
10500	150.08	61,834.63	811.71	274.24	41,487	61,849.78	274.31	1.49
10501	149.95	111,676.10	1,420.11	283.10	72,590	111,688.10	283.13	1.54
10510	330.00	173,467.70	2,107.64	296.30	107,682	173,477.70	296.31	1.61
10520	150.00	166,781.90	2,129.80	281.91	108,840	166,805.00	281.95	1.53
10530	330.00	167,350.40	2,002.18	300.90	102,307	167,368.90	300.94	1.64
10540	149.99	167,936.50	2,171.15	278.46	110,928	167,955.40	278.49	1.51
10550	330.00	182,686.10	2,185.63	300.91	111,625	182,708.90	300.94	1.64
10560	149.95	50,964.20	713.52	257.14	36,450	50,976.38	257.20	1.40
10570	330.00	169,650.10	1,914.26	319.05	97,778	169,674.60	319.09	1.74
10580	150.00	170,224.20	2,373.67	258.17	121,237	170,251.90	258.21	1.40
10590	330.00	170,794.40	1,932.39	318.19	98,683	170,819.30	318.23	1.73
10600	150.00	171,372.00	2,408.37	256.16	122,943	171,394.30	256.20	1.39
10610	329.99	171,944.60	1,973.83	313.60	100,654	171,971.70	313.65	1.71
10620	150.00	172,526.00	2,228.77	278.67	113,821	172,552.70	278.71	1.52
10630	329.99	173,107.20	2,071.27	300.87	105,767	173,117.70	300.89	1.64
10640	150.00	173,678.20	2,285.24	273.60	116,679	173,717.20	273.66	1.49
10650	330.00	174,241.00	2,078.06	301.85	106,054	174,259.80	301.88	1.64
10660	150.02	170,546.40	2,295.89	267.42	117,202	170,629.10	267.55	1.46
10661	150.30	12,235.09	162.75	270.64	8,309	12,240.17	270.76	1.47
10670	330.02	175,385.20	2,015.34	313.29	102,870	175,406.60	313.33	1.71
10680	149.98	176,000.70	2,395.90	264.45	122,285	176,032.10	264.50	1.44
10690	330.02	176,549.30	2,031.00	312.94	103,638	176,578.80	312.99	1.70
10700	149.98	177,148.20	2,442.52	261.10	124,584	177,190.60	261.16	1.42
10710	330.02	177,687.60	2,048.94	312.20	104,381	177,703.50	312.23	1.70
10720	149.99	109,044.80	1,435.14	273.54	73,217	109,074.90	273.61	1.49
10730	330.01	178,841.50	2,142.00	300.57	109,263	178,872.20	300.63	1.64
10740	149.98	179,467.90	2,359.71	273.80	120,402	179,538.20	273.91	1.49
10750	330.00	180,002.50	2,163.74	299.49	110,297	180,020.10	299.51	1.63
10760	150.00	180,586.20	2,376.40	273.57	121,158	180,615.30	273.61	1.49
10770	330.00	180,772.50	2,117.34	307.36	107,926	180,817.20	307.43	1.68
10780	150.00	180,745.90	2,389.62	272.30	121,650	180,789.80	272.36	1.49
10781	150.00	180,745.20	2,413.85	269.56	123,002	180,775.30	269.61	1.47
10790	330.02	180,718.50	2,144.20	303.42	109,156	180,741.30	303.46	1.66
10791	330.01	180,716.80	2,109.18	308.45	107,350	180,734.50	308.48	1.68

**Table 2b. Barrow / Dampier ALF Survey Line Navigation Summary.**



Line	Heading (Deg)	Straight Line Distance (m)	Acquisition Time (seconds)	Avg Straight Line Velocity (km/hr)	Points	Flight Distance (m)	Avg Flying Velocity	Avg Point Spacing (m)
10800	149.99	180,689.80	2,575.25	252.59	131,192	180,739.60	252.66	1.38
10810	330.03	180,665.00	2,049.49	317.34	104,400	180,693.40	317.39	1.73
10820	150.00	180,635.10	2,540.28	255.99	129,387	180,670.20	256.04	1.40
10830	330.00	114,454.10	1,334.30	308.80	67,924	114,466.60	308.84	1.69
10840	149.99	180,580.00	2,346.71	277.02	119,677	180,610.20	277.07	1.51
10850	329.99	180,551.00	2,159.44	301.00	110,126	180,579.40	301.04	1.64
10860	150.00	180,524.20	2,404.48	270.28	122,610	180,549.20	270.32	1.47
10870	330.00	180,496.60	2,138.87	303.80	109,006	180,517.80	303.84	1.66
10880	150.00	180,469.00	3,801.79	170.89	146,126	237,639.00	225.03	1.63
10890	330.01	180,441.70	2,059.55	315.40	100,632	180,471.80	315.46	1.79
10900	150.00	180,413.70	2,501.57	259.63	127,485	180,448.00	259.68	1.42
10910	330.00	180,385.90	2,073.93	313.12	105,591	180,421.30	313.18	1.71
10920	150.01	180,360.30	2,456.84	264.28	122,843	180,390.00	264.33	1.47
10930	330.00	180,332.20	2,053.22	316.18	102,663	180,357.70	316.23	1.76
10940	150.00	180,305.00	2,475.50	262.21	123,777	180,340.50	262.26	1.46
10950	330.00	180,224.50	2,059.74	315.00	103,038	180,247.10	315.03	1.75
10961	149.98	165,864.60	2,129.14	280.45	106,458	165,942.00	280.58	1.56
10970	330.00	180,219.00	2,128.36	304.83	106,420	180,280.90	304.94	1.69
10980	149.98	180,194.20	2,363.38	274.48	118,170	180,235.10	274.54	1.53
10990	330.30	8,843.90	106.76	298.22	5,339	8,845.16	298.26	1.66
11000	150.00	179,438.50	2,404.34	268.67	120,219	179,473.50	268.72	1.49
11010	330.00	178,833.70	2,053.54	313.51	102,751	178,860.60	313.55	1.74
11020	150.01	178,233.20	2,417.74	265.39	120,888	178,269.20	265.44	1.47
11030	330.00	177,594.90	2,048.60	312.09	102,482	177,659.30	312.20	1.73
11040	150.01	177,020.80	2,425.04	262.79	121,254	177,052.10	262.84	1.46
11050	330.00	175,670.40	2,028.09	311.83	101,407	175,692.00	311.87	1.73
11060	149.99	173,343.80	2,298.86	271.46	114,945	173,365.30	271.49	1.51
11070	330.00	171,064.50	2,024.25	304.23	101,214	171,088.20	304.27	1.69
11080	149.99	168,738.00	2,350.92	258.39	117,548	168,776.60	258.45	1.44
11090	330.00	166,484.80	1,942.76	308.50	97,138	166,513.30	308.55	1.71
11100	149.99	164,167.60	2,327.12	253.96	116,358	164,208.30	254.03	1.41
11110	330.00	161,789.10	1,873.72	310.85	93,738	161,810.00	310.89	1.73
11120	150.00	159,548.00	2,307.84	248.88	115,394	159,588.70	248.94	1.38
11130	330.01	157,212.60	1,831.84	308.96	91,593	157,227.30	308.99	1.72
11170	149.99	84,466.17	1,033.59	294.20	52,706	84,476.27	294.23	1.60
11180	150.00	62,851.63	862.35	262.38	43,119	63,989.10	267.13	1.48
11190	330.00	143,398.10	1,680.12	307.26	84,008	143,453.20	307.38	1.71
11200	149.98	140,801.10	1,934.06	262.08	96,997	140,833.00	262.14	1.45
11210	330.00	138,811.50	1,631.98	306.21	81,617	138,831.80	306.25	1.70
11220	150.02	140,719.70	2,020.79	250.69	101,040	141,860.50	252.72	1.40
11230	330.00	144,873.10	1,672.44	311.85	83,624	144,888.40	311.88	1.73
11240	149.97	136,977.30	1,757.26	280.62	87,865	138,363.50	283.46	1.57

**Table 2c. Barrow / Dampier ALF Survey Line Navigation Summary.**

Line	Heading (Deg)	Straight Line Distance (m)	Acquisition Time (seconds)	Avg Straight Line Velocity (km/hr)	Points	Flight Distance (m)	Avg Flying Velocity	Avg Point Spacing (m)
11250	330.02	136,111.40	1,632.32	300.19	81,618	136,127.10	300.22	1.67
11260	150.01	131,782.70	1,695.77	279.77	84,790	131,812.90	279.83	1.55
11270	330.03	135,345.00	1,632.76	298.42	81,640	135,377.70	298.49	1.66
11280	149.99	133,593.10	1,734.77	277.23	86,740	133,624.90	277.30	1.54
11290	330.04	126,604.60	1,524.10	299.05	76,488	126,631.60	299.11	1.66
11300	149.98	120,649.50	1,593.27	272.61	79,665	121,879.30	275.39	1.53
11310	330.02	121,131.40	1,417.75	307.58	70,889	121,155.50	307.64	1.71
11320	149.98	118,557.20	1,562.29	273.19	78,116	118,584.80	273.26	1.52
11330	330.04	115,882.80	1,361.33	306.45	68,068	115,919.00	306.55	1.70
11340	150.00	129,603.10	1,719.79	271.30	85,991	129,634.40	271.36	1.51
11350	330.01	134,343.10	1,603.74	301.57	80,189	134,415.20	301.73	1.68
11360	149.97	109,543.50	1,457.31	270.61	72,866	109,564.90	270.66	1.50
11370	329.99	120,932.50	1,443.44	301.61	72,174	120,968.30	301.70	1.68
11380	330.04	105,748.00	1,265.83	300.75	63,293	105,764.10	300.79	1.67
11390	149.96	101,432.70	1,275.73	286.23	63,787	101,449.40	286.28	1.59
11400	330.02	100,663.60	1,199.31	302.16	59,967	100,675.10	302.20	1.68
11410	150.02	96,681.32	1,230.77	282.79	61,540	96,700.18	282.85	1.57
11420	330.00	94,558.91	1,122.79	303.19	56,141	94,566.94	303.21	1.68
11430	149.96	92,631.44	1,190.31	280.16	59,517	92,652.09	280.22	1.56
11440	330.01	98,260.82	1,169.29	302.52	58,466	98,274.40	302.57	1.68
11450	149.97	87,095.70	1,165.31	269.07	58,266	88,198.13	272.47	1.51
11461	330.01	81,242.48	936.97	312.15	47,708	81,256.07	312.20	1.70
11471	149.98	78,875.15	1,085.52	261.58	55,271	78,899.95	261.66	1.43
11481	330.02	76,610.40	886.82	311.00	45,199	76,623.66	311.05	1.70
11490	149.99	89,176.88	1,187.77	270.29	58,915	89,205.20	270.37	1.51
11491	149.97	74,305.45	1,027.57	260.32	52,308	74,328.69	260.40	1.42
11501	330.03	72,015.18	831.37	311.84	42,311	72,026.43	311.89	1.70
11510	150.01	75,794.19	1,016.31	268.48	50,816	75,809.95	268.54	1.49
11520	330.45	6,858.16	80.64	306.17	4,033	6,860.32	306.27	1.70
11530	149.99	71,894.40	967.75	267.45	48,388	71,912.77	267.51	1.49
11540	330.00	98,285.49	1,166.60	303.30	58,331	98,310.57	303.37	1.69
<b>Total</b>		<b>19,925,266.29</b>	<b>251,688.01</b>		<b>12,693,822.00</b>	<b>19,991,853.44</b>		

**Table 2d. Barrow / Dampier ALF Survey Line Navigation Summary.**

The navigation parameters were acceptable. The sensor altitude was usually within  $\pm 10\text{m}$  of the nominal 80m but occasionally approached a 20m deviation. The altitude tended to be higher than 80m rather than lower. On some lines the altitude was not recorded correctly. Lateral flight path deviation was usually less than  $\pm 50\text{m}$ . Flying speed sometimes changed significantly during a line and varied considerably between lines

## Appendix 3. Fluor Picking Notes

Fluors were picked in a two stage process:

Stage 1: an SQL query was used to select a number of possible fluors

Stage 2: confident fluors were selected manually from the list of possible fluors.

Two interpretations were made during this study. A first pass interpretation was used to quickly produce an initial fluor map. The second refined interpretation was more thorough and was used to produce the final fluor maps.

The following query was used to select possible fluors in the first pass interpretation:

```
SELECT * FROM [RawAlfData] WHERE Ch_50 > Ch_27 / 10 ORDER BY Ch_50 DESC
```

The Barrow / Dampier ALF survey contains 12,693,822 spectra.

2275 fluors were picked in the first pass interpretation of the regional data (excluding the Goodwyn lines).

92 fluors were picked in the first pass interpretation of the Goodwyn lines.

3911 fluors were picked in the refined interpretation of the regional lines.

105 fluors were picked in the refined interpretation of the Goodwyn lines.

The following notes provide interpretation details for each sub-project:

### Part 1 fluor picking:

Part 1 of the project contains 1,850,161 fluors. The following SQL query reduces this to 6,037 fluors:

```
SELECT * FROM [RawAlfData] where Ch_50 > Ch_27 / 10 order by Ch_50 desc
```

Line 10890, point 249536 has negative values past 520nm.

Line 10880, point 438709 has negative values past 520nm.

Line 10880, point 435809 has negative values past 520nm.

Line 10880, point 438009 has negative values past 520nm.

Line 10890, point 276742 has high frequency noise.

Line 10890, point 276747 has high frequency noise.

Line 10910, 10880, 10900 and 10890 have high frequency noise.

After interpreting the first 200 records, the records became affected by high frequency noise. The following SQL query was used to remove the noisy lines:

```
SELECT * FROM [RawAlfData] where Ch_50 > Ch_27 / 10 and Line <> 10880 and Line <> 10890 and Line <> 10900 and Line <> 10910 order by Ch_50 desc
```

This reduces the number of possible fluors to 418.

Many of these records were also noisy, including many from line 10860.

168 fluors were selected in the refined fluor picking and saved in the Refined fluor picks table.

203 fluors were picked in the first pass picking. A third fluor picking session used the following SQL query:

```
SELECT * FROM [RawAlfData] WHERE Ch_50 > Ch_27 / 20 ORDER BY Ch_50 DESC
```

276 fluors were picked until the picking was stopped at record number 3580.

Because of the problems in picking low intensity fluors (found in Part 3) the picks obtained using the following query were added to the existing picks:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 10 ORDER BY Ch\_50 DESC**

This query selected 6,037 spectra.

Noisy lines were removed using the following query:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 10 and Line <> 10880 and Line <> 10890 and Line <> 10900 and Line <> 10910 ORDER BY Ch\_50 DESC**

This query selected 418 spectra. Many of these were noisy records from line 10860.

346 fluors were picked in total.

### **Part 2 fluor picking:**

Part 2 of the project contains 1,974,929 fluors. The following SQL query reduces this to 139,085 fluors:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 20 ORDER BY Ch\_50 DESC**

332 fluors were picked until the picking was stopped at record number 3600.

These picks are saved in the table: Refined fluor picks.

These picks were further refined by adding fluors picked using the query:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 10 ORDER BY Ch\_50 DESC**

This query selected 1238 fluors, many of which were noisy records from line 11200. A total of 395 fluors were picked in the further refined table: Refined2 fluor picks.

### **Part 3 fluor picking:**

Part 3 of the project contains 1,963,451 fluors. The following SQL query reduces this to 144,351 fluors:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 20 ORDER BY Ch\_50 DESC**

474 fluors were picked until the picking was stopped at record number 3500.

The fluor group to the south of Greenshank-1 was missing on the refined fluor picking so it was refined a second time adding picks using the SQL query:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 10 ORDER BY Ch\_50 DESC**

This query reduced the number of spectra to 16,317.

Line 11490 was noisy and was excluded from the picking using the following SQL query:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 10 AND Line <> 11490 ORDER BY Ch\_50 DESC**

This query reduced the number of spectra to 1,543.

A total of 678 fluors were picked when these picks were added.

The second fluor picking refinement added the low intensity fluor cluster south of Greenshank-1.

**Part 4 fluor picking:**

Part 4 of the project contains 1,868,877 fluors. The following SQL query reduces this to 35,951 fluors:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 20 ORDER BY Ch\_50 DESC**  
450 fluors were picked until the picking was stopped at record number 3500.

These picks were further refined by adding fluors picked using the query:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 10 ORDER BY Ch\_50 DESC**  
This query selected 294 fluors. A total of 468 fluors were picked in the further refined table: Refined2 fluor picks.

**Part 5 fluor picking:**

Part 5 of the project contains 1,795,569 fluors. The following SQL query reduces this to 64,949 fluors:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 20 ORDER BY Ch\_50 DESC**  
701 fluors were picked until the picking was stopped at record number 3250.

These picks were further refined by adding fluors picked using the query:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 10 ORDER BY Ch\_50 DESC**  
This query selected 390 fluors. A total of 723 fluors were picked in the further refined table: Refined2 Fluors.

**Part 6 fluor picking:**

Part 6 of the project contains 1,936,081 fluors. The following SQL query reduces this to 119,842 fluors:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 20 ORDER BY Ch\_50 DESC**  
585 fluors were picked until the picking was stopped at record number 3800.

These picks were further refined by adding fluors picked using the query:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 10 ORDER BY Ch\_50 DESC**  
This query selected 11,135 fluors.

The following query was used to remove noisy records from line 10500:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 10 AND Line <> 10500 ORDER BY Ch\_50 DESC**

This query selected 2,053 fluors.

A total of 708 fluors were picked in the further refined table: Refined2 fluors.

**Part 7 fluor picking:**

Part 7 of the project contains 1,289,702 fluors. The following SQL query reduces this to 338,666 fluors:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 20 ORDER BY Ch\_50 DESC**  
444 fluors were picked until the picking was stopped at record number 3500.

These picks were further refined by adding fluors picked using the query:

**SELECT \* FROM [RawAlfData] WHERE Ch\_50 > Ch\_27 / 10 ORDER BY Ch\_50 DESC**  
This query selected 1,246 fluors.

A total of 699 fluors were picked in the further refined table: Refined2 fluors.

Versions of the fluor picks were created excluding the Goodwyn region fluors using the queries:

**SELECT \* FROM [Refined fluors] Where Line < 10010 Or Line > 10140**

**SELECT \* FROM [Refined2 fluors] Where Line < 10010 Or Line > 10140**

The refined fluor table, named No Goodwyn Refined fluors, contains 376 fluors. The final refined fluor table, named No Goodwyn Refined2 fluors, contains 594 fluors.

### **SQL Query Notes:**

Records from the Goodwyn lines were excluded from a data table using the following SQL constraint:

**where Line < 10010 or Line > 10140**

These lines could be selected using the following constraint:

**where Line >= 10010 and Line <= 10140**

The following constraint provides an alternative way to select a series of lines:

**where Line in (10010, 10020, 10030, 10040, 10050, 10060, 10070, 10080, 10090, 10100, 10110, 10120, 10130, 10140)**

A series of lines can be excluded using this constraint:

**where Line not in (10010, 10020, 10030, 10040, 10050, 10060, 10070, 10080, 10090, 10100, 10110, 10120, 10130, 10140)**

## **Appendix 4. CD Contents**

The CD contains the following files:

**Barrow Dampier MkIII ALF Project.zip**

the *ALF Explorer™* project

**Barrow Dampier MkIII ALF Survey Interpretation Report.doc**

the interpretation report document file

**BarrowDampierFluors.txt**

ASCII data file of the final fluors selected during the interpretation  
(excluding the Goodwyn survey lines).

**GoodwynFluors.txt**

ASCII data file of the final fluors selected over the Goodwyn survey lines.

**Barrow Dampier MkIII ALF Survey Summary.xls**

Survey summary spreadsheet.

**Figures**

Directory containing figures used in the interpretation report: