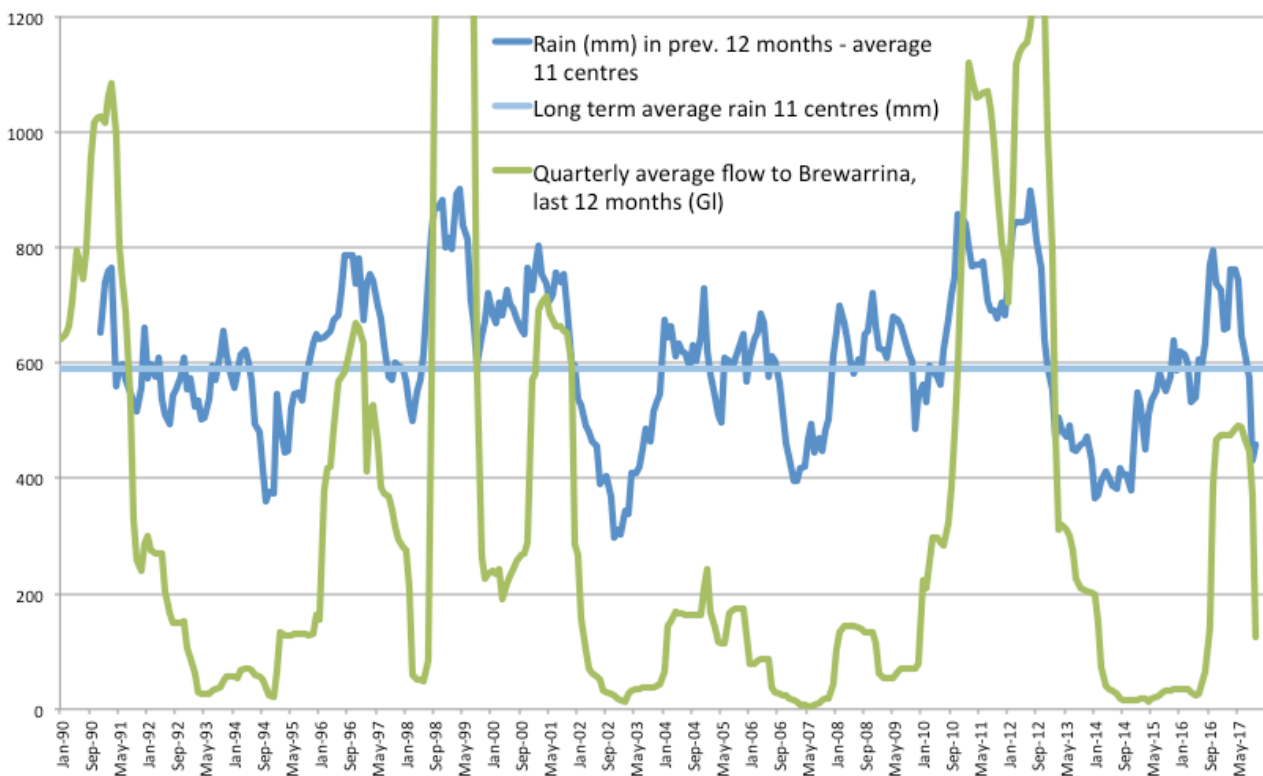


Supplementary Submission to Senate Standing Committee On Rural & Regional Affairs  
The integrity of the Water Market in the Murray Darling Basin  
Brewarrina Hearing

My original submission (registered no 3) showed the major change in the relationship between rainfall in the Darling basin and flows to the lower Darling over the 110 years to 2000 – and the major factor in this change was extractions from the river for irrigation. This supplement shows that **this conclusion also holds for the reduction in flows to Brewarrina**. Methodology is the same as my original submission, except that ‘average annual rainfall’ is adjusted to exclude centres in the original sample that don’t affect flows to Brewarrina – and add an additional centre (Walgett).

As was the case with flows to the lower Darling, rainfall averaged over the last 16-30+ years has been around (or above) its long term **average yet flows at Brewarrina have been about (or less than half) what they were in earlier periods**. Over the last 20-30 years, **significant flows at Brewarrina only occur in periods of ‘above average’ rainfall**. This can be seen in the following graph – which shows ‘average rainfall across 11 centres in the previous 12 months’ with flow at Brewarrina in the previous 12 months.



The attached table shows annual data for the last 125 years for ‘flow at Brewarrina’ and ‘average rainfall for 11 centres upstream of Brewarrina’ – and the respective longer term averages over a range of periods (shown in bold type). The figures in plain type show the data for the 11 centres used to compile the rainfall aggregates. Colour coding is used to try and highlight periods of high and low rainfall – and periods of low river flows. Lower flows have become much more common in recent years than have periods of low rainfall.

Rob Foster  
November 2017

The integrity of the water market in the Murray-Darling Basin  
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	Rainfall (mm)											Average	Flow at
	Brewarrina	Walgett	Collarenebri	Mungindi	Moree	Wee Waa	Wallangra	Glen Innes	Manilla	Mudgee	Gilgandra	11 Centres	Brewarrina (GL)
1890	758	819	684	1013		1012	1095	1174	1130	951	953	959	
1891	657	634	515	695		670	887	882	656	861	819	728	
1892	337	368	590	594		702	927	1140	825	870	587	694	6700 +
1893	396	520	535	782		675	896	978	761	805		705	16296
1894	510	555	594	757		854	849	803	924	740	700	729	9367
1895	389	447	554	491		504	594	607	670	554	449	526	1150
1896	449	454	418	420		541	833	934	748	660	601	606	1560
1897	400	553	366	477		514	752	879	534	445	467	539	2298
1898	319	341	267	307		442	546	629	501	766	559	468	1553
1899	282	363	319	291		471	823	951	581	505	498	508	1005
1900	168	336	218	308		466	699	883	612	757	454	490	2414
1901	257	409	413	326		557	530	700	505	651	350	470	771
1902	154	172	174	168		239	345	701	432	349	267	300	2
1903	369	619	706	689		707	907	1200	853	634	706	739	6191
1904	300	440	480	554		621	693	838	680	571	363	554	2800
1905	362	404	434	407		522	681	729	670	563		530	2000
1906	513	611	548	534		562	822	868	556	760		642	1850
1907	473	543	638	539		799	741	668	755	536		632	1400
1908	381	547	560	605		853	641	758	708	505		618	2995
1909	413	449	497	612		788	689	827	662	718		628	1931
1910	391	421	516	510		718	854	927	831	622	517	631	5877
1911	345	458	479	456		670	677	806	511	684	650	574	2836
1912	287	307	438	375		473	756	609	422	377	324	437	971
1913	319	543	541	552	671	634	683	846	517	493	468	570	2674
1914	226	334	414	785	698	556	695	836	554	673	521	572	1969
1915	150	295	270	238	455	474	445	552	545	562	343	394	583
1916	432	656	617	600	879	692	1025	1030	855	946	741	770	5185
1917	383	513	488	535	628	712	860	975	689	765	584	648	4998
1918	221	266	279	269	359	375	412	537	446	485	303	359	972
1919	153	274	234	356	336	365	277	491	450	346	282	324	111
1920	436	569	607	587	668	720	660	915	908	929	702	700	3200
1921	708	677	917	688	917	986	1109	1320	899	971	806	909	5900
1922	211	331	397	364	450	577	481	544	535	416	328	421	284
1923	328	266	244	386	366	378	441	559	404	500	478	395	365
1924	405	549	519	617	719	669	818	1076	815	738	618	686	1632
1925	506	491	514	560	497	385	600	803	483	430	479	523	668
1926	542	512	478	417	401	686	445	652	554	930	694	574	1400
1927	272	346	334	524	571	444	592	778	545	411	334	468	512
1928	338	335	429	449	635	525	672	877	831	649	410	559	1703
1929	114	247	310	332	634	419	624	775	458	422	310	422	1000
1930	372	491	446	502	605	434	783	803	567	762	562	575	1000
1931	569	678	639	584	779	821	831	1041	710	632	742	730	3127
1932	248	277	372	331	494	367	600	727	594	553	440	455	621
1933	624	573	460	503	623	576	888	1129	856	715	508	678	1496
1934	364	525	526	545	679	631	934	1033	712	775	697	675	1698
1935	178	261	237	204	399	365	634	616	529	464	347	385	792
1936	411	508	396	389	457	395	641	617	621	700	534	515	460
1937	242	312	452	366	528	430	651	745	588	525	409	477	886
1938	215	308	387	433	470	535	694	896	507	458	412	483	665
1939	553	507	521	542	472	495	583	692	577	575	663	562	671
1940	215	274	270	399	414	336	608	557	432	429	239	379	140
1941	407	432	288	424	583	469	560	730	672	563	532	515	2000
1942	634	576	724	487	597	787	743	929	862	673	683	700	2000
1943	373	361	399	386	519	547	639	732	632	563	423	507	842
1944	229	208	273	186	332	306	494	839	475	423	406	379	578
1945	308	366	405	289	524	490	659	1013	548	633	651	535	1107
1946	275	254	311	324	631	321	587	686	322	495	228	403	259
1947	641	748	755	681	648	649	787	987	773	798	755	747	1423
1948	430	618	519	437	467	494	706	864	555	678	558	575	1655
1949	442	666	600	557	660	702	733	1025	863	828	637	701	1898
1950	940	922	949	1074	1019	1064	1189	1170	980	1442	1273	1093	12462
1951	251	339	375	416	452	312	532	785	486	609	584	467	3000
1952	417	392	322	582	677	505	898	1137	838	771	676	656	3149
1953	424	379	441	535	500	536	671	630	568	495	484	515	1747
1954	397	521	550	557	731	667	809	958	667	741	622	656	1794
1955	662	799	769	600	732	803	780	872	952	976	951	809	3653
1956	713	813	808	742	865	1056	943	1155	893	1100	904	908	25000
1957	185	261	247	319	341	315	455	549	439	452	331	354	461
1958	528	441	535	557	667	724	699	814	562	745	616	626	871
1959	589	779	806	730	867	721	918	1188	577	736	606	774	2556
1960	333	353	328	378	475	421	627	627	458	598	510	464	1084
1961	431	582	435	549	679	720	751	772	686	674	569	623	1000
1962	697	716	562	719	690	607	803	890	682	661	527	687	2550
1963	719	615	544	742	817	703	742	971	851	899	747	759	2447

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1964	426	497	677	542	623	714	654	860	866	767	562	653	2191
1965	<u>255</u>	<u>210</u>	<u>279</u>	<u>331</u>	<u>368</u>	<u>352</u>	<u>431</u>	634	<u>380</u>	<u>435</u>	<u>292</u>	<u>361</u>	<u>117</u>
1966	329	405	401	470	606	574	668	818	543	688	400	537	775
1967	<u>233</u>	<u>322</u>	<u>215</u>	<u>305</u>	<u>423</u>	<u>392</u>	558	731	<u>454</u>	<u>469</u>	<u>374</u>	<u>407</u>	469
1968	380	601	494	543	591	658	675	808	784	700	803	640	2008
1969	375	506	542	682	668	645	780	884	780	<u>982</u>	<u>956</u>	709	1406
1970	374	602	443	439	811	615	1023		728	907	692	663	831
1971	469	451	488	518	820	630	859	1028	785	665	636	668	4988
1972	355	403	382	418	610	589	718	988	579	589	403	549	713
1973	634	604	456	593	672	826		974	777	<u>1274</u>	<u>1000</u>	781	2065
1974	<u>713</u>	605	711	652	493	670	583	761	458	615	589	623	4658
1975	417	550	455	546	780		969	992	763	601	492	657	1651
1976	677	597	767	<u>785</u>	840	894	1004	964	781	764	663	794	6173
1977	421	615	528	628	613	<u>934</u>	722	1052	838	529	482	669	3569
1978		743	690	696	741	679	<u>1067</u>	<u>1200</u>	<u>979</u>	929	695	<u>842</u>	<u>3348</u>
1979	<u>196</u>	338	351	384	487	383	560	703	524	560	<u>383</u>	443	803
1980	<u>177</u>	363	<u>339</u>	<u>321</u>	<u>413</u>	<u>335</u>	651	<u>496</u>	<u>456</u>	<u>458</u>	407	<u>401</u>	<u>272</u>
1981	381	518	376	<u>350</u>	487	456	741	796	582	831	509	548	805
1982	<u>180</u>	309	<u>333</u>	487	596	<u>364</u>	658	787	525	<u>302</u>	401	449	859
1983	572	662	766	<u>824</u>	<u>939</u>	870	<u>1154</u>	1057	771	828	770	838	4196
1984	557	609	740	632	896	709	904	993	759	827	784	765	4425
1985	396	402	445	509	632	484	725	738	564	654	<u>379</u>	539	578
1986	318	364	<u>318</u>	315	437	424	720	626	544	549	412	457	471
1987	439	380	581	493	660	685	758	878	804	717	574	634	<u>309</u>
1988	453	621	573	621	760	682	989	938	738	644	622	695	2991
1989	393	547	432	417	633	693	808	925	598	764	505	610	2543
1990	559	483	690	487	532	597	674	940	678	920	607	652	4101
1991	297	640	601	566	654	875	710	<u>942</u>	699	700	580	660	1141
1992	365	<u>361</u>	470	439	540	420	709	814	580	757	644	554	423
1993	378	519	563	521	514	584	603	726	661	679	645	587	<u>230</u>
1994	<u>236</u>	<u>284</u>	<u>320</u>	<u>248</u>	<u>386</u>	<u>281</u>	617	671	<u>350</u>	<u>427</u>	<u>277</u>	<u>372</u>	<u>78</u>
1995	581	637	649	<u>537</u>	693	697	806	794	615	640	504	650	656
1996	443	552	694	<u>655</u>	636	723	<u>1207</u>	1091	890	<u>983</u>	734	783	2639
1997	372	362	437	614	775	637	739	881	750	501	423	590	1128
1998	604	494	646	<u>533</u>	<u>901</u>	871	910	990	<u>958</u>	<u>1037</u>	833	798	6106
1999	604	454	668	661	784	678	853	<u>886</u>	661	<u>850</u>	827	721	941
2000	678	555	693	555	567	706	877	<u>792</u>	614	<u>1036</u>	832	719	2276
2001	<u>218</u>	<u>297</u>	454	573	812	<u>560</u>	840	1041	617	<u>638</u>	483	594	1147
2002	<u>161</u>	<u>177</u>	<u>242</u>	<u>233</u>	<u>262</u>	<u>260</u>	<u>441</u>	<u>565</u>	370	483	<u>224</u>	<u>311</u>	<u>71</u>
2003	<u>279</u>	347	355	350	669	496	685	851	617	877	474	545	<u>178</u>
2004	356	487	<u>856</u>	<u>761</u>	<u>919</u>	<u>968</u>	871	856	<u>746</u>	626	561	728	841
2005	<u>230</u>	385	546	474	573	639	<u>589</u>	718	606	888	603	568	513
2006	<u>202</u>	<u>243</u>	415	366	605	<u>389</u>	512	<u>885</u>	559	<u>347</u>	<u>284</u>	437	<u>76</u>
2007	598	562	572	455	580	448	585	885	741	733	557	611	<u>168</u>
2008	563	561	599	558	779	<u>616</u>	726	784	720	805	600	665	460
2009	558	570	482	362	527	<u>419</u>	<u>713</u>	830	479	<u>446</u>	573	542	<u>316</u>
2010	<u>722</u>	<u>815</u>	800	<u>776</u>	714	<u>921</u>	802	941	723	<u>1084</u>	<u>1050</u>	<u>850</u>	<u>3307</u>
2011	417	382	587	648	<u>953</u>	<u>676</u>	<u>884</u>	1031	838	565	529	683	3122
2012	503	508	453	510	722	<u>566</u>	534	691	669	<u>763</u>	588	592	3993
2013	<u>239</u>	<u>248</u>	<u>297</u>	<u>312</u>	566	418	611	601	<u>650</u>	502	<u>365</u>	437	806
2014	370	<u>270</u>	351	439	537	<u>372</u>	658	642	<u>446</u>	559	553	472	<u>64</u>
2015	<u>270</u>	341	372	405	615	595	929	897	726	676	631	587	<u>137</u>
2016	409	608	645	678	673	656	764	900	889	918	851	726	1898
2017													<u>150</u>

	Brewarri Walgett	Collarenebri	Mungindi	Moree	Wee Waa	Wallangra	Glen Innes	Manilla	Mudgee	Gilgandra	Average 11 Centres	Brewar-rina (GL)
<b>Averages</b>											<b>591</b>	
<b>1892-1916</b>	<b>400</b>	<b>466</b>	<b>489</b>	<b>501</b>	<b>618</b>	<b>587</b>	<b>725</b>	<b>842</b>	<b>650</b>	<b>673</b>	<b>555</b>	2245
<b>1892-1960</b>	383	456	470	486	585	573	701	834	638	647	538	2670
<b>post 1960</b>	421	480	514	522	648	606	756	853	668	709	580	1715
<b>post 1980</b>	414	460	528	510	654	595	760	844	659	710	577	1500
<b>post 1990</b>	410	434	522	506	659	577	715	822	648	711	588	1129
<b>post 2000</b>	381	425	502	494	657	562	697	820	650	682	558	1069
30% below ave.	<u>280</u>	<u>326</u>	<u>342</u>	<u>350</u>	<u>433</u>	<u>411</u>	<u>508</u>	<u>589</u>	<u>455</u>	<u>471</u>	<u>388</u>	<u>414</u>
5 percentile	180	254	250	278	366	324	431	552	429	413	284	
95 percentile	709	779	830	769	901	916	1049	1138	897	977	887	
Standard deviation	161	156	169	173	159	181	177	177	156	199	189	

**Notes**

Rainfall data from BoM website. To minimise gaps, missing observations were replaced by nearest reasonable alternative.

Partly estimated numbers and splicing breaks are marked by underlining or borders.

The main BoM station numbers (and alternates) used are listed below. Selection criteria were outlined in original submission.

Primary	48015	52026	48031	52020	53033	53044	54036	56013	55031	62021	51018
secondary	48176	52088	48015&8				54104	56243	55303	62101	51161

