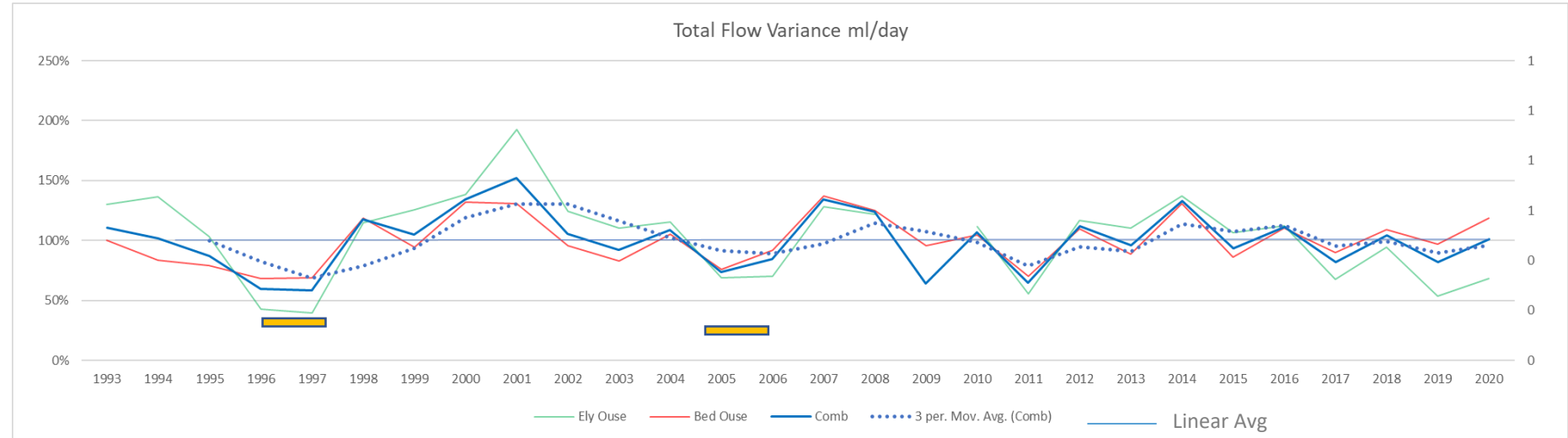


This is the 10th publication of this model. It follows the gate 2 submission and metrics.

It focuses using the Bedford Ouse as the sole source of supply as defined by Mott at the meeting.

Source modelling by Kelvin Allen Based on 1993-2020 actuals



It is very evident from the graph, that using any annualised monthly average to derive base flows doesn't reflect the changing annual trends in flows and any prolonged drought period as highlighted above then becomes hidden.

The model demonstrates this by using actual daily flows and demand output on the reservoir and counts the number of days the reservoir is unable to sustain the demand.

This shows that some particularly long dry periods have a significant impact on water availability and as such become the limiting factor for any solution. The period 96-97 & 2004-05 in particular.

Ouse Washes Water Levels (+1.4 AOD)

Source modelling by Kelvin Allen Based on 1993-2022 actuals

Welney IV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1993			1.60	3.09	1.33	2.41	0.84	0.76	1.95	1.01	3.38	3.35	1.97
1994	3.57	2.93	2.87	2.67	1.38	0.74	0.73	0.72	0.72	1.06	2.35	2.51	1.85
1995	2.44	1.27	1.24	0.97	1.25	0.72	0.72	0.72	1.30	0.92	1.08	3.21	1.32
1996	2.46	2.49	2.38	1.22	0.64	1.06	0.84	0.59	0.61	0.54	0.83	1.01	1.22
1997	1.07	1.28	1.41	1.28	2.07	0.87	0.88	0.59	0.55	0.72	1.12	2.18	1.17
1998	3.06	2.33	1.25	4.00	1.54	1.42	1.26	0.57	0.63	1.59	2.96	2.97	1.97
1999	2.95	2.43	2.11	1.39	0.54	0.62	0.69	0.66	0.71	1.16	1.27	2.73	1.44
2000	2.49	2.01	2.68	2.88	2.03	2.30	0.91	0.60	0.68	2.28	3.53	2.99	2.12
2001	2.99	3.47	3.19	2.58	1.72	0.67	1.04	0.61	0.67	2.19	1.95	1.96	1.92
2002	2.13	2.31	2.00	1.46	0.99	0.63	1.05	1.16	0.61	1.50	2.79	3.06	1.64
2003	4.13	2.60	1.36	0.69	0.56	0.48	0.48	0.53	0.57	0.66	1.38	1.63	1.26
2004	2.41	2.78	1.49	1.30	2.25	1.04	0.68	1.16	1.11	1.82	2.32	2.07	1.70
2005	1.89	2.00	2.03	1.84	1.23	0.67	0.59	2.53	0.61	0.58	1.13	1.28	1.36
2006	1.45	1.66	1.95	1.84	1.20	0.89	0.69	0.82	0.70	1.54	3.09	3.10	1.58
2007	3.28	2.95	3.18	1.66	1.32	2.09	2.27	2.21	1.57	2.42	2.54	2.69	2.35
2008	3.63	2.25	2.83	2.23	1.32	2.31	1.24	0.57	1.92	1.53	2.84	2.60	2.11
2009	2.56	3.54	2.18	1.30	0.58	0.61	0.59	0.90	0.63	0.66	1.40	2.53	1.46
2010	2.90	2.95	3.56	1.75	1.07	0.65	0.57	1.12	1.14	0.62	1.29	1.58	1.60
2011	2.62	2.16	2.30	0.79	0.61	0.67	0.66	0.63	2.02	0.68	0.97	1.16	1.27
2012	1.24	1.34	1.49	1.13	3.22	1.84	2.32	1.86	0.83	2.17	3.93	3.99	2.11
2013	3.43	3.20	3.13	2.18	1.41	0.70	0.60	1.33	2.26	3.16	3.57	3.53	2.38
2014	3.15	1.34	2.64	2.26	0.71	1.43	0.77	1.80	2.83	2.73	2.88	2.62	2.10
2015	1.81	0.87	0.56	0.58	0.61	0.58	0.72	1.34	1.73	3.13	3.16	3.22	1.53
2016	2.84	2.10	0.65	2.01	0.86	0.51	0.81	0.75	2.29	2.17	2.56	2.60	1.68
2017	1.97	1.03	1.36	0.73	0.85	0.91	0.87	1.03	1.77	3.30	3.04	2.87	1.64
2018	3.51	2.64	1.62	0.90	0.73	0.76	0.86	1.30	1.47	2.17	2.34	1.91	1.68
2019	1.74	0.70	1.49	0.96	0.60	0.66	1.84	3.23	3.63	3.70	3.20	3.16	2.07
2020	1.87	0.81	0.79	0.72	0.89	0.93	2.89	2.82	3.81	4.04	4.03	2.54	2.18
2021	1.67	2.37	2.40	1.51	0.87	0.89	2.17	1.67	0.68	1.46	1.40	2.34	1.62
2022	2.40	2.30	2.43	1.55	0.79	0.69	0.63	0.63	0.67	0.90	3.23	2.28	1.54
Mean	2.54	2.14	2.01	1.65	1.17	1.02	1.04	1.17	1.36	1.75	2.39	2.52	1.73

Average monthly flows by year from the Bedford Ouse in 3m/sec.

This uses derived flows from Earith gauging station between 1993 – 2021

Shows periods impacting the SPA with flooding



Source modelling by Kelvin Allen

Based on 1993-2020 actuals

Over 27 years the flow trend at Denver mirrors that seen at Earith and lesser extend onto the Ouse Washes and the Middle Level.

The model uses the actual daily CEH data from Denver and Offord until 1993 then Earith level data, ML monthly pumped volumes from 2010, then modelled on the river Nene.

This clearly shows the opening of the Earith sluices during Winter flows.

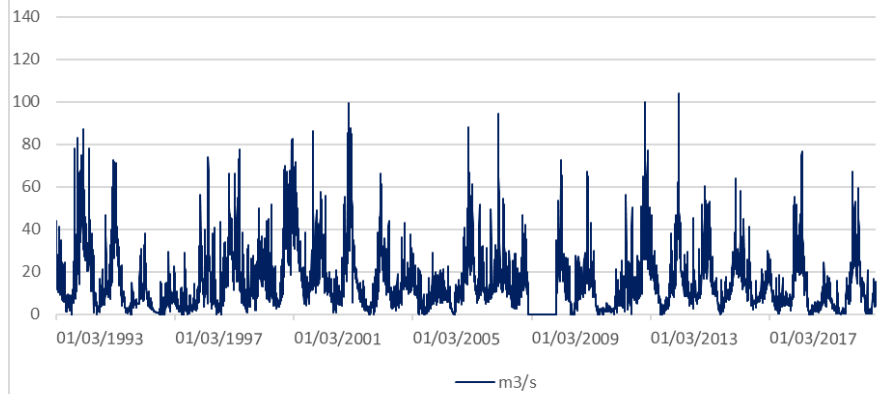
The actual Q flow equates to the following:

Source	Q	Base	Climate Change
Denver	33	16.6m ³ /sec	12 m ³ /sec
Earith	34	24.73m ³ .sec	18 m ³ /sec
Middle Level	30	1.21m ³ /sec	0.9 m ³ /sec

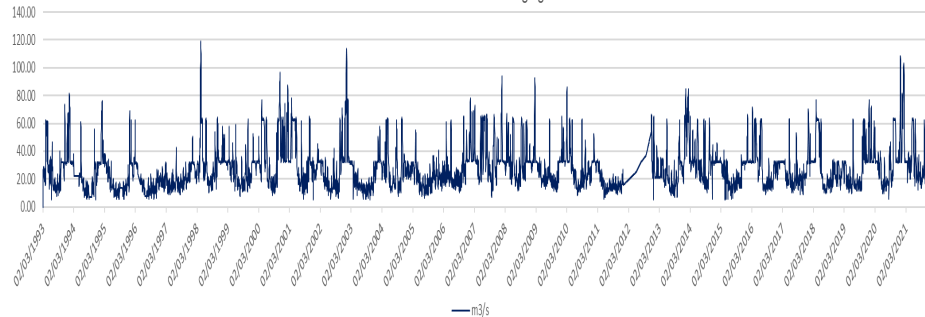
As all water on the Ouse Washes passes through Earith, it is managed for flood by levels rather than specific Q values.

Abstracted water at Earith would be limited by a Q34 constraint.

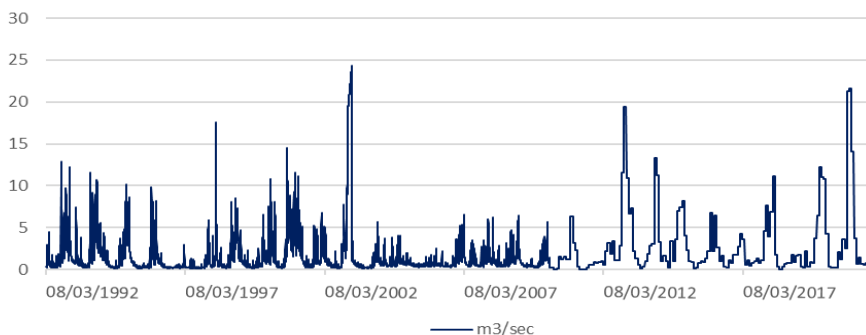
Eky Ouse Denver Flow Data
1993 - 2020



Bedford Ouse Derived Flow Data
1993 - 2021 taken off Earith Gauging Station



Middle Level Pumped System Flows



Based on these scenarios and data from David Ocio analysis and assumptions

Source modelling by Kelvin Allen
Based on 1993-2020 actuals

I have modelled the following Parameters:

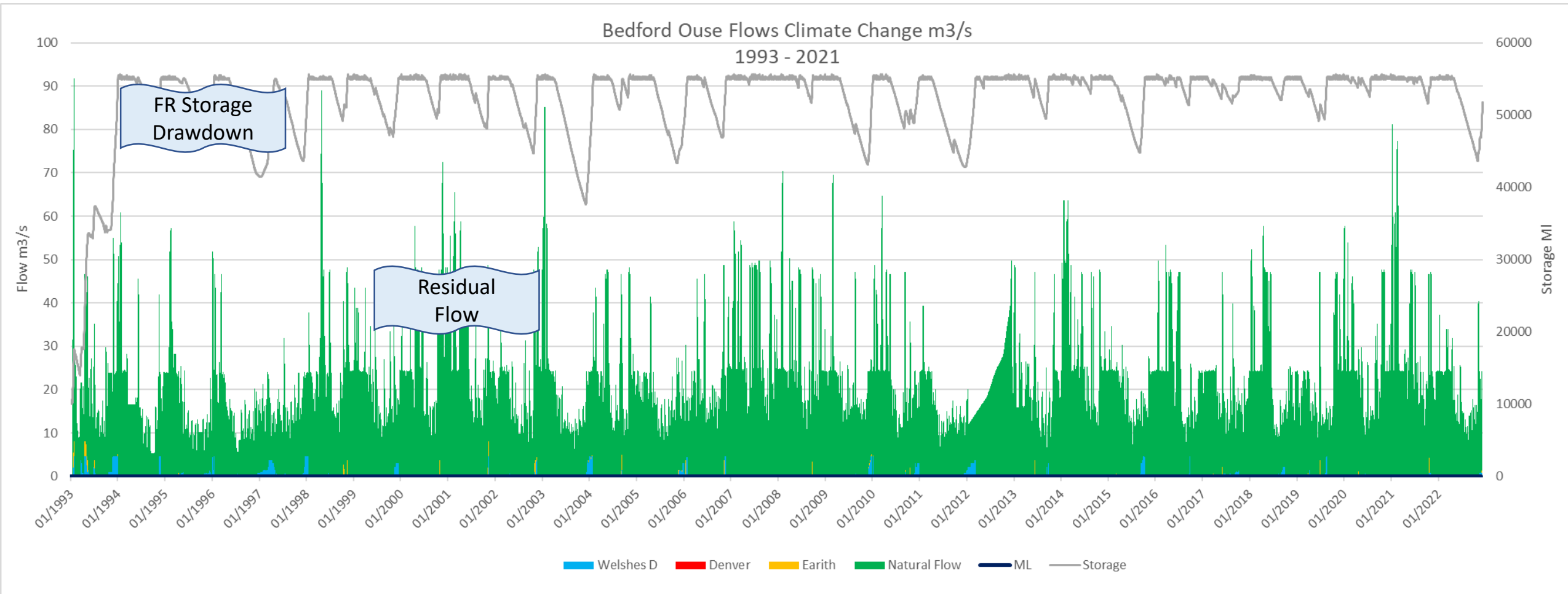
Scenario	1
Percentile	34
% Climate Change	75%
Abstraction Denver	
Abstraction Earith	3.47
Abstraction Welshes Dam	4.63
Abstraction Middle Level	0.0
Nene Stanground Flow	
East FR Capacity MCM	
West FR Capacity MCM	55
East FR Output ml/day	
West FR Output ml/day	85
% FR Minimum Storage	10.0%
Washes Q Constraint Switch	TRUE
Ouse Washes ++ DM	3.1
Ouse Washes ++	0
River Delph in Channel Max	1
Av Days Capture East	0
Av Days Capture West	222
Zero Output	0

	East FR	West FR	Total Ely Ouse	Total Bedford Ouse	Denver	Earith	Welshes Dam	Middle Level	Resudual Flow Denver	Resudual Flow Welmore	Storage East FR	Output East FR	Zero Output
Year	Days > Qx	Days > Qx	ml/day	ml/day	0.00	3.47	4.63	0.00	MI/d	MI/d	MI/d	MI/d	Days
Averages	0	222	320245	653497	0	7327	25002	0	320245	621168	32329	30957	0
1993	0	284	445634	654153	0	17939	57388	0	445634	578825	75,327	31025	0
1994	0	232	468244	543497	0	2904	28340	0	468244	512253	31,244	31025	0
1995	0	304	353852	514736	0	4411	24124	0	353852	486201	28,534	31025	0
1996	0	278	146392	446644	0	962	18889	0	146392	426792	19,851	31110	0
1997	0	355	135956	447065	0	1139	41678	0	135956	404248	42,817	31025	0
1998	0	189	393407	774490	0	11246	21808	0	393407	741436	33,054	31025	0
1999	0	251	431058	614787	0	7726	23217	0	431058	583843	30,943	31025	0
2000	0	149	475453	859951	0	11047	19858	0	475453	829046	30,905	31110	0
2001	0	179	660448	852528	0	11714	19268	0	660448	821546	30,982	31025	0
2002	0	257	427648	621808	0	9050	22192	0	427648	590566	31,242	31025	0
2003	0	258	378635	538705	0	1944	21281	0	378635	515479	23,226	31025	0
2004	0	188	395415	687765	0	11683	27224	0	395415	648857	38,908	31110	0
2005	0	222	237066	493562	0	2427	23708	0	237066	467427	26,135	31025	0
2006	0	230	241699	598464	0	7166	29033	0	241699	562265	36,199	31025	0
2007	0	83	440457	894765	0	7942	23035	0	440457	863788	30,977	31025	0
2008	0	136	416989	815514	0	9535	21387	0	416989	784593	30,922	31110	0
2009	0	276	11586	624338	0	4974	25827	0	11586	593538	30,801	31025	0
2010	0	241	383747	682201	0	8814	22184	0	383747	651204	30,998	31025	0
2011	0	295	189603	457002	0	695	19683	0	189603	436624	20,378	31025	0
2012	0	154	401417	713506	0	6841	35275	0	401417	671390	42,116	31110	0
2013	0	188	377746	576620	0	5360	25380	0	377746	545879	30,740	31025	0
2014	0	160	469450	853627	0	12296	18915	0	469450	822416	31,210	31025	0
2015	0	266	366295	563076	0	4379	26609	0	366295	532088	30,989	31025	0
2016	0	191	384511	721036	0	10591	20505	0	384511	689940	31,096	31110	0
2017	0	269	232052	585057	0	6661	24589	0	232052	553807	31,250	31025	0
2018	0	169	324149	712246	0	7047	23863	0	324149	681335	30,910	31025	0
2019	0	229	184066	632675	0	6376	24649	0	184066	601650	31,025	31025	0
2020	0	186	234382	774577	0	10553	20338	0	234382	743686	30,891	31110	0
2021	0	186	0	845851	0	12188	19192	0	0	814471	31,380	31025	0

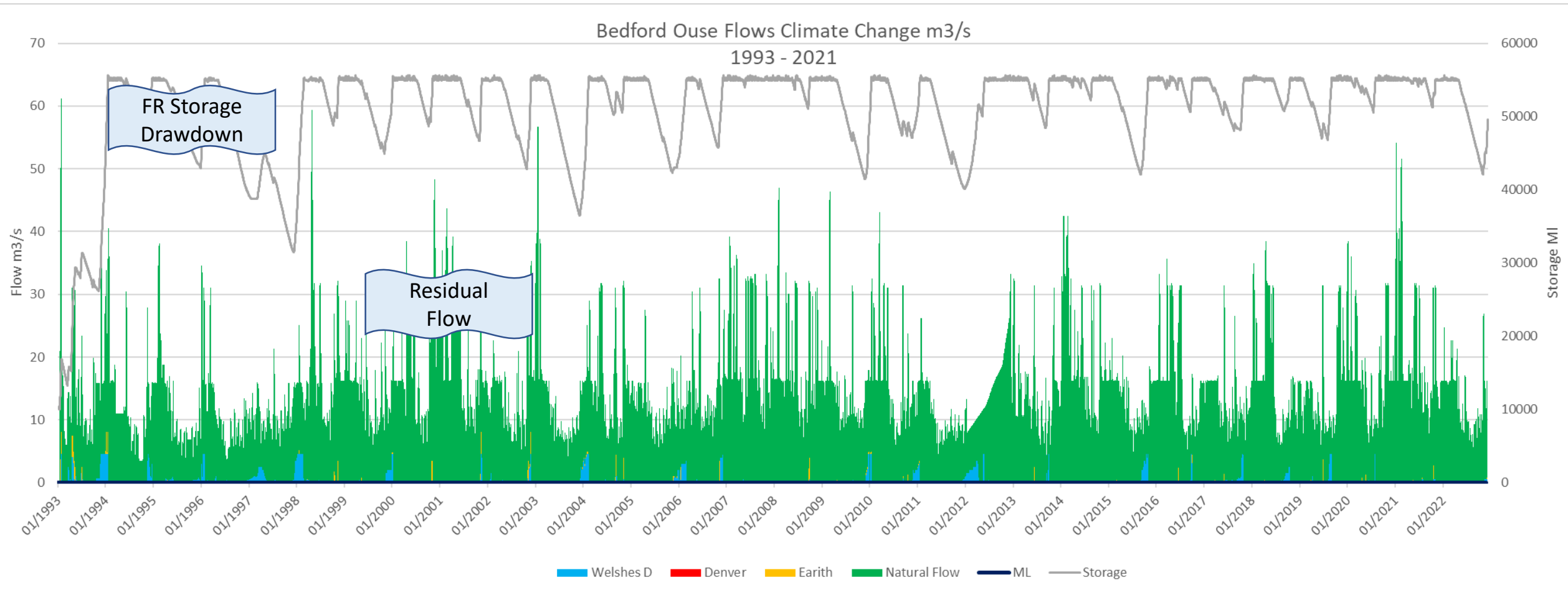
Measures 1993 - 2021

Average Days Captured per year

Total Number of days Zero output



Abstraction @ Q34 - CC 75% of historic - FR37A 55 MCM - PWS 87 ml/day - Denver 0m3/sec Earith 3.47 m3/sec Welches Dam 4.63 m3/sec



Abstraction @ Q34 - **CC 50% of historic** - FR37A 55 MCM - PWS 87 ml/day - Denver 0m³/sec Earith 3.47 m³/sec Welches Dam 4.63 m³/sec

FR37A Site Specifics

This doesn't reflect on the Ouse Washes WLMP for water passed through Earith Sluice, just on the availability of water.

Pushing to Q60 or 4.9 m³/sec HOF is the breakpoint

This would place more constraints on available water.

