WP4.4

HP Kirchbichl Description, Alternatives and MCA tree

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Short Description
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Document Control

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Introduction

The hydropower-plant near Kirchbichl (Tyrol, Austria) is one of the biggest diversion-type hydroelectric plant in Tyrol. The total water discharge of the river Inn between October and May for the operation of the hydropower-plant is used, hence no water donation for residual flow is available for several months. For the implementation of the WFD and in order to reach (maintain) the status “good ecological potential, several pilot investigation are planned. One of these will measure the dotation of the residual-water and in the framework of this different discharge experiments (depth-velocity measurements) will be conducted. The discharge experiments at the Inn meander were planned and realized by the TIWAG (the Tyrolean Hydropower Company) and included the field works assessing different hydromorphological components like water discharge, water velocity, water depth and width of the riverbed. The next step was the comparison of these results with the national guidelines regarding the minimum ecological requirements.

Inn meander discharge

Image 1 shows a general view over the River Inn meander, the hydro-electric facility, and the two approximate position of the gauging stations at the Inn meander and below to the HP plant. The gauging station of the Inn meander is located in the middle of the loop (Image 1). Table 2 is given the average daily discharge of the meander in the year 2002. The gauging station Bichlwang is located below the hydro-electric facility and the Inn meander. This gauging station is measuring the discharge from the hydropower plant and the discharge from the Inn meander (Image 1). Table 1 shows the average daily discharge of the gauging station in the year 2002.

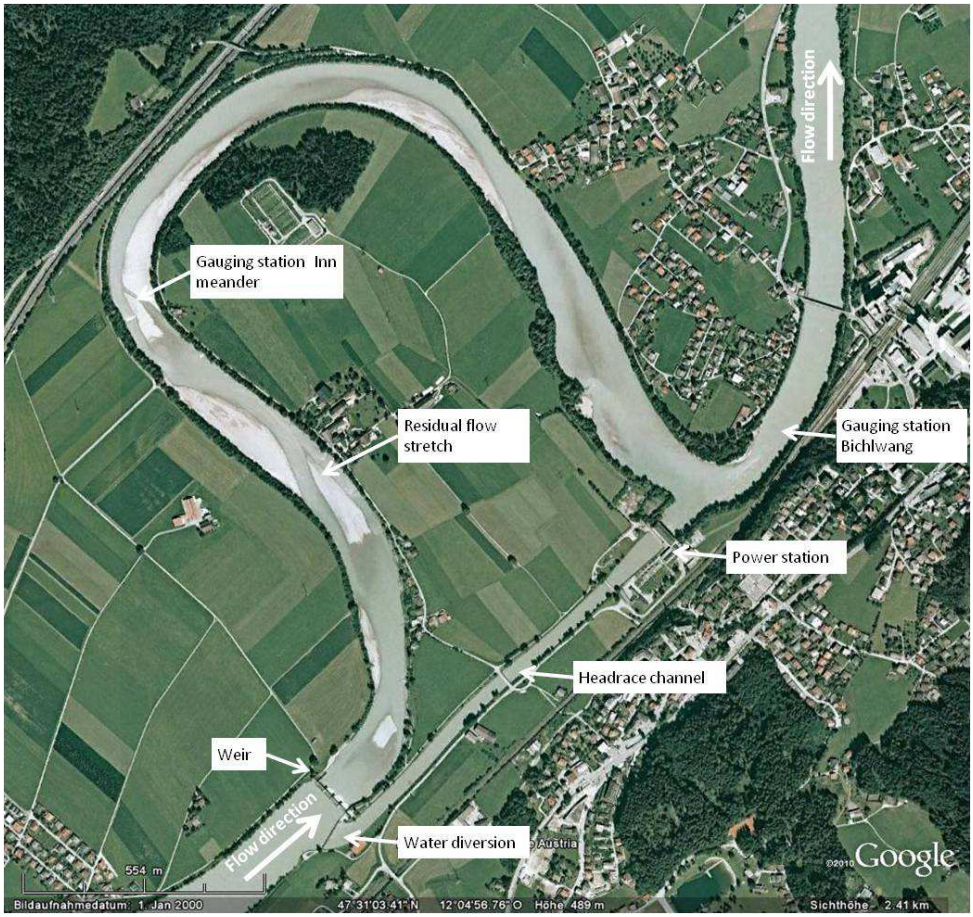

Image 1: Inn meander and the description of the hydro-electric facilities.

Table 1: Discharge Kirchbichl-Bichlwang (average daily discharge in m³/sec)

Average daily discharge at the Inn gauging station near Bichlwang (2002)												
Day	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	109	137	184	203	252	440	418	452	299	240	196	285
2	98.2	122	161	217	294	446	467	395	331	240	181	264
3	134	109	119	253	382	504	458	357	370	232	203	277
4	156	119	143	244	548	577	641	388	330	222	278	277
5	151	132	169	260	510	617	530	446	354	200	299	283
6	105	143	159	237	392	788	448	465	321	187	279	241
7	130	151	155	220	354	703	411	672	291	230	253	213
8	168	140	159	235	330	573	400	506	265	237	237	179
9	177	115	158	261	330	499	464	436	275	229	218	208
10	170	123	137	227	362	529	470	378	328	219	206	256
11	171	117	140	235	384	514	441	412	332	215	226	254
12	152	125	177	222	360	481	401	940	309	211	269	251
13	110	136	171	202	391	519	484	835	290	192	249	247
14	110	176	168	187	440	563	445	692	269	200	257	208
15	158	158	170	206	431	577	417	579	223	226	301	159
16	142	130	152	231	481	571	477	492	230	230	444	180
17	127	104	132	219	529	674	643	428	253	271	639	223
18	129	119	128	197	558	732	629	358	262	386	438	204
19	105	163	178	186	645	738	491	388	256	246	424	212
20	89.3	159	458	191	552	777	400	429	271	224	390	205
21	95.7	155	424	160	507	809	328	524	250	245	327	188
22	113	166	433	166	563	724	377	510	238	270	320	180
23	121	140	343	196	596	615	366	440	271	260	313	191
24	118	114	259	308	562	721	374	393	401	261	264	167
25	116	148	237	289	500	718	420	317	322	241	294	148
26	120	159	247	266	530	620	398	356	296	209	339	159
27	104	153	249	299	544	580	333	402	299	191	339	165
28	186	170	242	248	575	660	288	412	297	209	312	175
29	160		195	244	522	569	344	386	226	235	298	169
30	130		207	262	430	424	462	376	220	240	288	171
31	132		213		433		450	315		230		179

Table 2: Discharge Kirchbichl Inn meander (average daily discharge in m³/sec)

Average daily discharge at the Inn meander gauging station near Kirchbichl (2002)												
Day	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.010	0.011	0.011	0.047	0.014	103	93.4	121	5.24	0.034	0.021	0.018
2	0.011	0.011	0.011	0.042	2.51	107	137	64.7	7.26	0.026	0.020	2.61
3	0.011	0.011	0.011	0.041	48.8	168	128	8.7	41.9	0.026	0.021	12.5
4	0.011	0.011	0.012	0.035	226	236	314	121	8.25	0.043	0.024	15
5	0.011	0.011	0.011	0.034	181	276	193	177	28	0.023	0.730	21.1
6	0.011	0.011	0.010	0.030	55.9	455	116	215	0.976	0.023	0.102	0.125
7	0.011	0.011	0.011	0.022	42.2	354	80	426	0.172	0.022	0.023	0.020
8	0.011	0.011	0.012	0.019	5.59	230	75.3	232	0.104	0.019	0.024	0.016
9	0.116	0.011	0.011	0.018	7.36	160	136	165	0.081	0.020	0.026	16.8
10	0.402	0.011	0.011	0.020	30.1	195	139	109	14.8	0.020	0.024	61.7
11	0.352	0.012	0.013	0.017	47.7	181	111	148	7.54	0.021	0.023	60.8
12	0.013	0.011	0.013	0.018	26.3	149	73.4	869	0.647	0.020	0.024	58.2
13	0.011	0.011	0.013	0.021	55.9	189	154	831	0.365	0.021	0.023	54.1
14	0.011	0.838	0.012	0.018	102	233	111	502	0.045	0.020	0.026	16.2
15	0.010	0.021	0.011	0.019	94.2	245	92.5	303	0.038	0.019	7.95	1.78
16	0.010	0.012	0.013	0.028	144	241	149	222	0.03	0.024	147	0.029
17	0.012	0.011	0.013	0.054	191	341	511	155	0.028	20.5	389	0.017
18	0.010	0.011	0.013	0.012	222	398	294	88.7	0.027	57.4	123	0.012
19	0.010	0.260	0.015	0.014	304	405	159	121	0.024	0.231	96.3	0.011
20	0.011	0.012	163	0.014	214	441	71.6	160	0.023	0.048	56.9	0.011
21	0.012	0.012	87.5	0.057	170	472	8.88	226	0.024	0.029	5.38	0.010
22	0.011	0.011	97.7	0.044	226	391	53	173	0.024	0.054	2.99	0.011
23	0.011	0.011	27.1	0.012	257	278	42.5	111	0.025	0.087	2.42	0.01
24	0.011	0.011	0.384	15.5	244	390	49.5	98.4	71.8	0.035	0.046	0.01
25	0.011	0.011	3.87	0.134	161	379	91.9	5.1	5.41	0.024	5.68	0.009
26	0.011	0.011	1.14	0.022	187	284	69.7	60.6	0.135	0.025	9.81	0.008
27	0.013	0.011	0.098	0.645	205	247	15.2	71.7	1.13	0.023	13.1	0.007
28	1.77	0.011	0.086	0.020	233	326	0.438	78.8	6.72	1.66	0.497	0.006
29	1.23		0.073	0.014	180	230	31.1	56.7	0.054	0.025	0.042	0.009
30	0.013		0.057	0.014	90.7	90.1	134	44.8	0.041	0.019	0.023	0.009
31	0.011		0.049		97.6		121	6.27		0.02		0.009

Dotation experiment in the Inn meander

The dotation experiment was conducted between 30th September and 2nd October 2009 by the TIWAG (Tyrolean Hydropower Corporation). Thereby, different hydromorphological components in 22 river cross-profiles like water discharge, water velocity, depth, and width of the riverbed was measured in experiment. The near-bed velocity and the maximum velocity was measure by a current meter. The discharges in the experiment was Q_{dot} = 0.4 m^3s^{-1}, Q_{dot} = 1 m^3s^{-1}, Q_{dot} = 3 m^3s^{-1}, Q_{dot} = 6 m^3s^{-1} und Q_{dot} = 13 m^3s^{-1}. Image 2 shows the Inn meander and the position of the 22 cross-profiles. Images 3 to 7 shows the water levels at a river section with different volumes of water Q_{dot} = 0.4 m^3s^{-1}, Q_{dot} = 1 m^3s^{-1}, Q_{dot} = 3 m^3s^{-1}, Q_{dot} = 6 m^3s^{-1} und Q_{dot} = 13 m^3s^{-1}

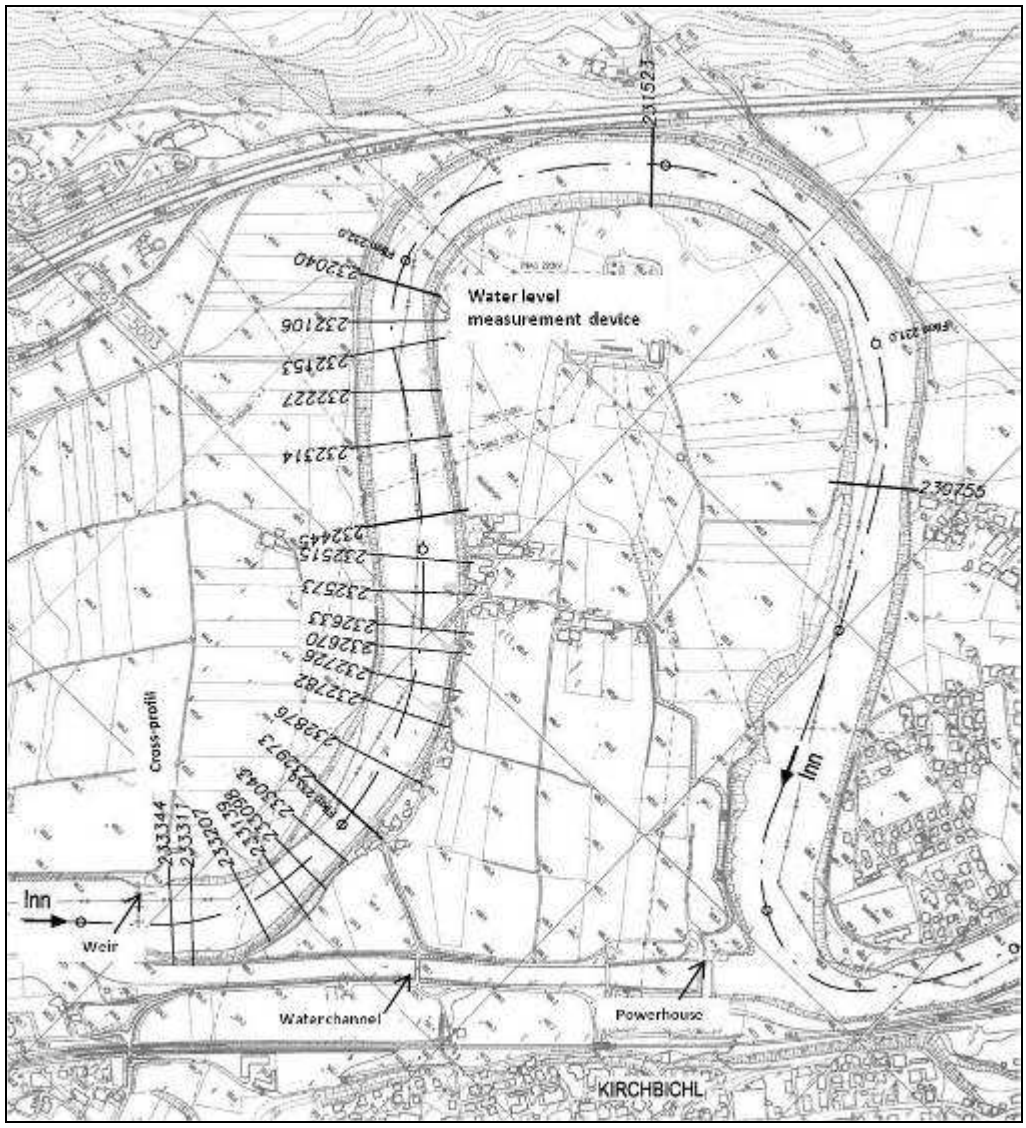

Image 2: The Inn meander and the position of the 22 river cross-profiles Picture: (TIWAG).

Image 3: Water level with 0.4 m³s-1 discharge. Near the gauging station at the Inn meander (Picture: TIWAG)

Image 4: Water level with 1 m³s-1 discharge. Near the gauging station at the Inn meander (Picture: TIWAG)

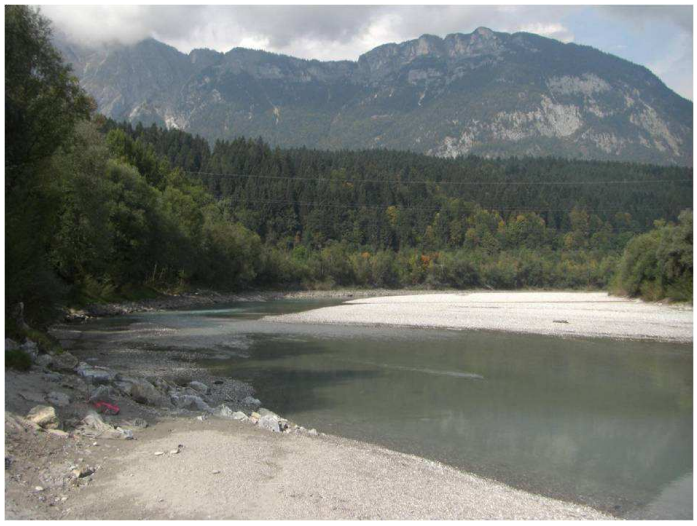

Image 5: Water level with 3 m³s-1 discharge. Near the gauging station at the Inn meander (Picture: TIWAG)

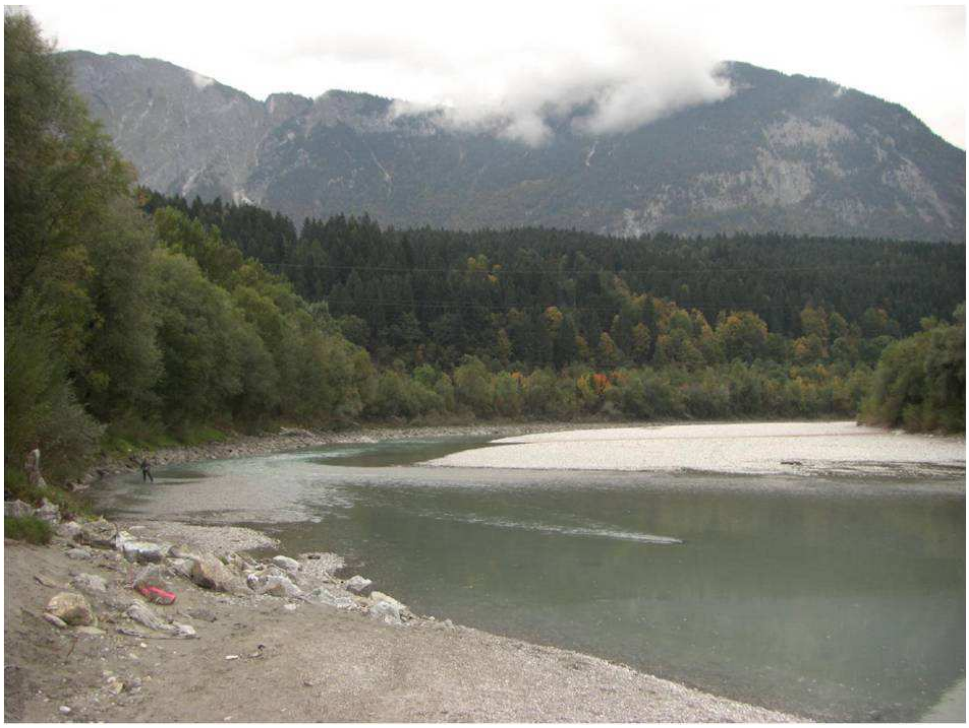

Image 6: Water level with 6 m³s-1 discharge. Near the gauging station at the Inn meander (Picture: TIWAG)

Image 7: Water level with Q_{dot} = 13 m^3s^{-1} discharge. Near the gauging station at the Inn meander (Picture: TIWAG)

Alternatives description

This chapter intends to describe the alternatives and the MCA decision tree (Image 8) of the HP Kirchbichl which are used in the SESAMO Program. The **ALTERNATIVES 0** represent the historical situation before the hydro-electric facility was installed in the Inn meander. For the implementation of the WFD and in order to reach (maintain) the status "good ecological potential, several pilot investigation are planned. The **ALTERNATIVE 1** to **3** are representing this planned pilot investigation and include some data of the discharge experiments. The discharge experiments at the Inn meander were planned and realized by the TIWAG (the Tyrolean Hydropower Company) and included the field works assessing different hydromorphological components like water discharge, water velocity, water depth and width of the riverbed.

ALTERNATIVE 0: The historical situation.
ALTERNATIVE 1: Current situation Q_{dot}=0.4 m³/s water dotation in the Inn meander
ALTERNATIVE 2: Water dotation in the Inn meander. Q_{dot}=6.0 m³/s water dotation.
ALTERNATIVE 3: Fish ladder at the upper side of the weir. Q_{dot}=13 m³/s water dotation.

MCA decision tree

Inn River

- HP Production
  - Annual power production kW
  - Linear annual power production
- Economy
- Environment
  - Hydromorphological Quality
    - Hydrological Regime
    - River Bed / grain size distribution
- Biological Quality
  - Bentic Macroinvertebrates
  - Fish fauna
  - Phytobenthos trophy EQR
  - Phytobenthos saprobic EQR
  - Phytobenthos refer EQR
  - Riparian Vegetation
- Physical chemical quality
  - Biological oxygen demand [BOD]
  - Dissolved organic carbon [DOC]
  - Oxygen saturation
  - pH

1) PHYTOBENTHOS

Phytobenthos - Module trophy (ground state oligo-mesotroph)

This indicator uses the phytobenthos community to describe the trophic status (nutrient loads) of a river stretch (EQR = ecological quality ratio). Phytobenthos is a very good indicator for organic pollutants and a good indicator or hydrologic alternations like hydropeaking water diversion, and impoundment. The ground state of this river stretch is oligo-mesotroph. (source: QZV Ökologie)

QUALITY CLASS	EQR	UF
1 = very good	≥ 0.88	1
2 = good	0.61 – 0.87	0.75
3 = moderate	0.47 – 0.60	0.5
4 = unsatisfactory	0.33 – 0.46	0.25
5 = bad	≤ 0.32	0

Phytobenthos - Module saprobic (ground state I-II B)

This indicator uses the phytobenthos community to describe the organic load of a river stretch (EQR = ecological quality ratio). The ground state of this river Inn stretch is I-II B. (source: QZV Ökologie)

QUALITY CLASS	EQR	UF
1 = very good	≥ 0.92	1
2 = good	0.75 – 0.91	0.75
3 = moderate	0.58 – 0.73	0.5
4 = unsatisfactory	0.42 – 0.57	0.25
5 = bad	≤ 0.41	0

Phytobenthos - Module reference species (bioregion type "H2")

This indicator uses the phytobenthos community to describe the deviation of the actual species community of study area to the expected reverence biocoenosis (EQR = ecological quality ratio). This assesses the synergetic effect of nutrient load, organic pollutants, hydrological, and toxic stressors in the river. The ground state of this river Inn stretch is I-II B. (source: QZV Ökologie, Quality Objectives Ordinances Ecology - Surface Waters)

QUALITY CLASS	EQR	UF
1 = very good	≥ 0.80	1
2 = good	0.50 – 0.79	0.75
3 = moderate	0.30 – 0.49	0.5
4 = unsatisfactory	0.16 – 0.29	0.25
5 = bad	≤ 0.15	0

2) BENTHIC MACROINVERTEBRATES

Macroinvertebrate - Module saprobic (saprobic ground state 1.75)

This indicator uses the benthic macroinvertebrates community to describe the saprobic status of a river stretch. The module saprobic describes nutrient load and the effect of the benthic macroinvertebrates communities. This method based on the Zelinka & Marvan (1961) saprobic index (source: QZV Ökologie, Quality Objectives Ordinances Ecology - Surface Waters).

QUALITY CLASS	SAPROBIC CLASS	UF
1 = very good	≤ 1.75	1
2 = good	1.76 – 2.21	0.75
3 = moderate	2.22 – 2,68	0.5
4 = unsatisfactory	2,69 – 3.14	0.25
5 = bad	≥ 3.14	0

Macroinvertebrate – Module general degradation

This indicator uses the benthic macroinvertebrates community to describe the general degradation of a river stretch. This module assesses the different hydromorphological stressors like impoundment, residual water, alternation in the catchment area and toxic substances (source: QZV Ökologie, Quality Objectives Ordinances Ecology - Surface Waters).

QUALITY CLASS	PARAMETER	UF
1 = very good	≥ 0.80	1
2 = good	0.60 – 0,80	0.75
3 = moderate	0.40 – 0.60	0.5
4 = unsatisfactory	0.20 – 0,40	0.25
5 = bad	< 0.20	0

3) FISH FAUNA

The Fish Index Austria describes the nativeness and the ecological status of river and streams. Due to the relative high lifetime and the life cycle, hence fish species are good indicators for the ecological and hydromorphological status of rivers and streams The index is based on the fish ecological typology of watercourses and on the fish ecological character species. The assessment is done after the criteria trophic situation (biomass), biocoenosis (character and companion species), ecological guilds (reproduction and current guilds), biocoenotic region (Fish Region Index) and population structure (character and companion species). The respective parameters in brackets are variably suited to indicate disturbances such as impoundment, surge, continuum discontinuity etc. The status of the water body according to the WFD is expressed as the deviation of the status to the respective reference status. (source: QZV Ökologie, Quality Objectives Ordinances Ecology - Surface Waters).

Fish Fauna - Fisch Index Austria

QUALITY CLASS	PARAMETER	UF
1 = very good	1.00 – 1.49	1
2 = good	1.50 – 2.49	0.75
3 = moderate	2.50 – 3.49	0.5
4 = unsatisfactory	3.50 – 4.49	0.25
5 = bad	4.50 – 5.00	0

4) HYDROLOGICAL QUALITY

The indicators river discharge measurement depth and the flow velocity has a strongly connection to the water discharge experiment conducted by the TIWAG (Tyrolean Hydropower Company). One of these will measure the dotation of the residual-water and in the framework of this different discharge experiments (depth-velocity measurements) will be conducted. The discharge experiments at the Inn meander were and included the field works assessing different hydrological components like water discharge, water velocity, and water depth. This discharge measurement assess the water depth and the flow velocity values of different residual water discharges in the Inn meander, and compares this with limit values. The quality classes of the flow velocity and water depth are described in the “QZV Ökologie” (Quality Objectives Ordinances Ecology - Surface Waters).

River discharge measurement depth [m]

QUALITY CLASS	DEPTH	UF
bad	0 – 0.29	0
moderate	0.40 – 0,39	0.5
good	0.40 – 2.5	1

River discharge measurement flow velocity (m/s)

QUALITY CLASS	FLOW VELOCITY	UF
bad	0 – 0.29	0
good	0.3 – 1.2	1

5) PHYSICAL CHEMICAL QUALITY

The biological oxygen demand (BOD) is the amount of dissolved oxygen needed for decomposition of organic material in a defined period of time. The DOC (dissolved organic carbon is a measure for organic contamination of the water body and oxygen depletion caused by microbial activity. The oxygen budget is one of the most essential parameters directly affecting the biocoenosis of a water body (Quality Objectives Ordinances Ecology - Surface Waters).

BOD – biological oxygen demand (mg/l), saprobic ground state 1.75

QUALITY CLASS	BOD [MG/L]	UF
very good	0 – 2.9	1
good	4.0 – 3.9	0.5
bad	4.0 – 6.0	0

DOC – dissolved organic carbon (mg/l), saprobic ground state 1.75

QUALITY CLASS	DOC [MG/L]	UF
very good	0 – 2.4	1
good	2.5 – 4.9	0.5
bad	5.0 – 6.0	0

6) MORPHOLOGICAL CHARACTERISTICS

This quality element describe the good and the very good status of a watercourse on basis of morphological characteristics such as bank dynamics, sole dynamics, river course, substrate composition, streambed structure and riparian vegetation. This parameter describes the actual status of river bank vegetation at the Inn meander. The assessment is done after the Quality aim directive (QZV Ökologie) on basis of the respective reference watercourse. For this PCS we use the just the riparian vegetation and the river connectivity. In case of the PCS a fish bypass the connectivity is given.

River bank vegetation

QUALITY CLASS	UF
1 = very good	1
2 = good	0.75
3 = moderate	0.5
4 = unsatisfactory	0.25
5 = bad	0

River connectivity

CONNECTIVITY	UF
yes	1
no	0

Annual energy production (GWh/a)

The annual energy protection for the HP Kirchbichl is stated with 141.1 GWh/a.

Energy production loss (GWh/a)

This Indicator shows the energy production loss in case of the dotation of residual water stretch. The dotation water for the Inn meander is unavailable for hydro-electric exploitation. Falser (2008) calculated yearly energy loss and the finance loss of the water dotation in the Inn meander. The yearly energy loss was calculated as energy production loss per year (GWh/a) per 1 m³/s dotation water.

DOTATION	ENERGY PRODUCTION LOSS (GWH/A)
0 – 20 m³/s	- 0.446 GWh/a per m³/s
20 – 50 m³/s	- 0.476 GWh/a per m³/s