BEFORE THE SOUTHLAND REGIONAL COUNCIL

IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER OF	Hearings of Application – APP-20171566 by Alliance Group Ltd (Mataura)
AND	Fish & Game New Zealand – Southland Region (submitter)

STATEMENT OF EVIDENCE OF TONY HAWKER ON BEHALF OF SOUTHLAND FISH & GAME COUNCIL

Dated: 28 November 2018

Southland Fish & Game Council
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1. My name is Tony Hawker.

Qualifications and experience

2. I hold a National Certificate in Conservation (2000) and in Environmental Science (1997) from the Nelson Marlborough Institute of Technology.

3. I have approximately 18 years of experience in the environmental field with the Department of Conservation (Canterbury Conservancy), Canterbury Regional Council (commonly known as 'Environment Canterbury' or 'ECan') and most recently Fish & Game New Zealand – North Canterbury Region[1] (Fish & Game).

4. I have been continually employed by Fish & Game based in Christchurch since 2008 as follows:

    a. Between 2008 – late 2012 I was employed by Fish & Game as an 'Environment Officer', which involved advocating for sports fish and game bird habitat in the Canterbury region through resource management and planning processes.

    b. Since late 2012, I have been employed by Fish & Game as a 'Field Officer', specialising in the management of trout fisheries in the Canterbury region.

       My role entails managing and reviewing Fish & Game's trout fishery population monitoring programmes, undertaking population assessments, compliance monitoring, field work and management and administrative work in relation to the sustainable management of trout fisheries in the Canterbury Region.

5. Since working for Fish & Game I have developed expertise in effective fish screening criteria for sports fish, including trout, as this was identified by Fish & Game as one of the critical issues for the maintenance of self-sustaining sports fish populations in Canterbury Rivers. This work includes:

    a. Reviewing consent conditions on behalf of Fish & Game in relation to criteria for effective fish screening;

    b. Carrying out fish salvage operations in relation to large consent holders, such as Amuri Irrigation Company;

    c. Working with large consent holders, such as Central Plains Water, to assess fish screens for effectiveness against consent conditions and Schedule 2 of the Canterbury Land and Water Regional Plan. This work has included regular physical inspections of various fish screens throughout Canterbury;

    d. Undertaking a research field trip to California and Washington States in the United States of America in April 2017 to investigate best practice in relation to fish screening; and

    e. Representing Fish & Game on the Fish Screen Technical Working Group (FSTWG) convened by the Regional Committee of the Canterbury Water Management Strategy. The FSTWG includes representatives from industry, Iwi, Environment Canterbury, environmental and fish groups and has a

[1] Otherwise known as the 'North Canterbury Fish & Game Council'.

mandate to review current good practice guidelines for fish screens, including monitoring procedures, improve fish screening and address technical challenges.

6. I am familiar with the *'Fish Screening: good practice guidelines for Canterbury'* (Jamieson et al, (2007)), including their application and associated technical challenges.

My colleague at Fish & Game – North Canterbury until mid-2009, Davor Bejakovich, authored in 2006 a report titled *'Criteria for Fish Screen Design in Canterbury – Sports Fish'*, which was widely accepted by other Fish & Game regions nationally. This 2006 report was peer reviewed and endorsed by overseas fish screening experts and was subsequently produced as a support document by the Fish Screen Working Party[2] that was involved in development of *'Fish Screening: good practice guidelines for Canterbury'* (Jamieson et al, (2007)).

7. I am an experienced and active trout and salmon angler. I have fished for trout and salmon intensively in Canterbury for the past 17 years and more extensively throughout the South Island for the past 25 years.

8. In preparing my evidence I have reviewed the following:

   a. The application and accompanying information provided by Alliance;

   b. The May 2018 report 'Review of Fish Screening Monitoring Provisions at Mataura Meatworks Hydro Intake' by Joe Hay, Cawthron Institute prepared for Department of Conservation, Ngai Tahu and Fish & Game;

   c. The s 42A report prepared by Stephen West on behalf of Environment Southland; and

   d. Evidence filed on behalf of the Alliance, including the evidence of Doyle Richardson, John Kyle and Mark James.

9. As referred to above, I am employed by Fish & Game – North Canterbury Region, a statutory body whose function under s 26Q(1) of the Conservation Act 1987 is to manage sports fish and game and their habitats in the Canterbury Region in the recreational interests of anglers and hunters. This includes in relation to planning:

   a. To represent the interests and aspirations of anglers and hunters in the statutory planning processes – 26Q(1)(e)(i); and

   b. To advocate the interests of the Council, including its interests in habitats – s 26Q(1)(e)(vii).

In this case, I have been asked by Fish & Game – Southland Region to give evidence on fish passage, fish screening and monitoring issues raised by the Alliance application. I am aware of, and in preparing this evidence have complied with, my overriding duty to assist the Hearing Commissioner impartially with matters within my area of expertise.

[2] Comprised of Environment Canterbury, Fish & Game New Zealand, Irrigation New Zealand and Department of Conservation.

10. I confirm I have read and agree to comply with the Code of Conduct of Expert Witnesses in the Environment Court Practice Note. This evidence is within my area of expertise, except where I state that I am relying on what I have been told by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope of evidence

11. I have been asked by Fish & Game to give evidence on issues raised by the Alliance application. This includes:

    a. The effects of the Alliance diversion, including the proposed monitoring methodology*;*

    b. Effectiveness of the proposed monitoring methodology; and

    c. Effective fish screen design.

Executive summary

12. The Mataura River supports a nationally significant brown trout fishery.

13. The Alliance diversion and take near the Mataura Falls does not incorporate an effective fish screen for the protection of native fish and brown trout, including juveniles, nor is one proposed.

14. Hydro-electric takes can cause significant loss and / or mortality of fish, particularly large fish moving downstream. The effects of the Alliance diversion and take for hydro-electric power generation are not fully understood nor are the downstream movements of brown trout past the Mataura Falls.

15. The principles of good fish screen design, as set out in the *'Fish screening: good practice guidelines for Canterbury'*, are relevant to:

    a. The question of how effective the modified trash screen is likely to be at excluding fish for the purposes of monitoring during the downstream adult eel migration period (January – May (inclusive)); and

    b. Assessing the effects of the Alliance diversion, including the proposed monitoring methodology.

    Reducing the bar gaps on the trash screen from 60mm to 20mm to facilitate monitoring does not constitute an effective fish screen. Bar gap spacing is only one element of seven criteria for effective fish screening that need to be considered in combination, i.e. it is not a one or the other scenario.

16. A significant limitation of the proposed monitoring methodology is that any conclusions about the downstream migration potential in the lower Mataura River or mortality / damage rates can only be taken from fish that are entrained, physically impinged on the modified trash screen and subsequently captured. The proposed monitoring programme:

    a. Will not provide any information on the proportion of fish, including species and age classes, that are diverted from the main mainstem and entrained in the intake channel;

b. Will be biased toward larger fish;

c. Is limited to the downstream eel migration period (January – May inclusive) and will not provide any information on numbers of fish being entrained and impinged at other times of the year, i.e. from June – December inclusive; and

d. It will provide no information on the fate of fish, including brown trout, that pass through the trash screen and turbine.

17. The proposed monitoring methodology effectively creates a trap and represents a worse outcome for brown trout than the status quo. This is because reducing the bar gaps on the trash screen from 60mm to 20mm is likely to have a two-fold effect, namely by:

a. Increasing the through screen velocity, which is likely to increase the rates of impingement and associated injury / mortality; and

b. Capturing brown trout between 200 – 450mm in length that currently have a chance of passing through the existing trash screen and turbine with some chance of survival, albeit dependent on their body length.

18. Fish & Game has a set of criteria for effective fish screen design that would ensure a satisfactory level of protection for both native fish and brown trout in the Mataura River.

Relevance and application of the *'Fish screening: good practice guidelines for Canterbury' 2007 ('the guidelines')* to the Alliance application

19. I understand that the changes Alliance proposes to make to the existing trash screen are intended to assist with monitoring the number of large downstream migrant eels diverted into the intake rather than to convert it into a functional fish screen per se. I acknowledge this point, however, I agree with Joe Hay (Hay, (2018)) that the principles of good fish screen design, as set out in the guidelines, are relevant to:

a. The question of how effective the modified trash screen is likely to be at excluding fish for the purposes of monitoring during the downstream adult eel migration period (January – May (inclusive)); and

b. Assessing the effects of the Alliance diversion, including the proposed monitoring methodology.

In addition, I note that:

a. The guidelines provide several a case studies about the implementation of high velocity closed conduit (Eicher and MIS) fish screens for hydro-electricity applications, which have been installed at North American facilities where flows range from 6 – 15m^3/s; and

b. The guidelines have been incorporated into Schedule 2 of the Canterbury Land and Water Plan in relation to surface water diversions or takes.

20. Surface water diversions are categorized into two general types, gravity and pump. Jamieson et al. (2007) provide New Zealand good practice guidelines for fish screening for gravity diversions up to 10m^3/s, i.e. equivalent to Alliance's gravity

diversion from the mainstem of the Matura River, and up to 500L/s pumped. Gravity diversions are typically characterized by open channels or canals leading off the stream channel where flow is controlled by differences in elevation (gravity). They are often accompanied by dams / weirs that divert flow into the channel. Pump diversions employ mechanical pumps to remove water from the river / stream. The pumps are typically either located directly in the stream (submersible) or on land with an intake pipe in the stream.

21. It is well recognised that there is a need for a “whole of intake design” if fish are to be efficiently and effectively diverted without damage from surface water intakes. Jamieson et al. (2007) conclude that a fish screen will only be effective when all the following factors are implemented in combination, i.e. it is not a one or the other scenario:

a. *Location* - The screen is located at, or as close as practical, to the point of water diversion form the mainstem to minimise exposure of fish to the screen structure and the length of channel affected. Consideration needs to be given to the risk of overtopping (which would make the screen ineffective), and the flood risk;

b. *Approach velocity* - Water velocity across the face of the screen is slow enough to allow fish to escape entrainment (being sucked or washed over the screen) or impingement (being squashed or rubbed against the screen). It is recommended that approach water velocity should not exceed 0.12m/s to protect small salmonid fish of about 30mm in size.

c. *Sweep velocity / angle* – Sweep velocity is the velocity of the water moving across or past the face of the screen, which is important in allowing the fish to swim away from the intake.is equal or greater than approach velocity to promptly sweep fish past the intake;

Screen angle, which is the angle of the screen relative to the flow of water. The closer a screen is to parallel to the flow of water, the greater the sweep velocity, which avoids an over-reliance on other screen factors to ensure the fish are unharmed. The screen angle should be no greater than 45° to the flow of the water.

d. *Bypass* - An effective fish bypass system is provided so that fish are taken away from the intake, which requires good sweep velocity to the bypass.

From a structural perspective, the bypass should be an open channel, rather than a pipe, to ensure that fish are returned to the waterway unharmed and less than 200m long to ensure fish are returned to the waterway as soon as possible.

e. *Bypass connectivity* – Relates to whether the bypass connects to the active channel and whether the connection is an easy pathway to return undamaged fish into the source channel. There needs to be connectivity between the fish bypass and somewhere safe, usually an actively flowing main stem of the waterway;

f. *Screen aperture size* – This considers the actual dimensions and mechanics of the screen installed (mesh, profile bar or perforated plate), which needs to have openings small enough to exclude fish and a smooth surface to avoid damage to fish.

For mesh, profile bars or perforated plates to be effective in excluding small salmonid fish of about 30mm in size the maximum screening opening size should not exceed 3mm for woven mesh screens, 2mm for profile bars screens and 3.2mm for perforated plate screens to protect the smallest salmonid fish about 30mm in size. Screen aperture size and condition is especially important if other factors such as approach or sweep velocity are considered unfavourable; and

g. *Operation and maintenance* – This considers whether the operator is operating the screen as it was designed, which requires frequent monitoring / visual inspections, and that it is effectively maintained on an ongoing basis, including the quality of any repairs that have been completed.

22. The seven effectiveness criteria represent a consistent baseline of what is expected from a functional fish screen and if any one of these seven criteria are not met, then the screen maybe ineffective at protecting fish. This is illustrated by the following 'Field Officer Monitoring Sheet' developed by Environment Canterbury to monitor fish screens in the Canterbury Region against the seven effectiveness criteria described above.[3]

[3] Environment Canterbury Fish Screen Pilot: Internal Summary Report & 2018 / 19 Fish Screen Improvement Campaign – August 2018, Table 3 – Effectiveness Assessment from Field Sheet.

Criteria	• Critical Factor	Effectiveness Grade					
		Effective		Ineffective – moderate *Modification of current screen and/or better management required to achieve effectiveness*		Ineffective – significant *Potential rebuild of screen required to achieve effectiveness*	
1	Location – risk of overtopping	No	☐			Yes	☐
	Location – flood risk	Low to Moderate	☐	High	☐		
2	Through screen velocity	**< 0.06 or 0.12 m/s**	☐	**> 0.06 or 0.12 m/s** *(If this can be achieved with minor intake adjustments)*	☐	**> 0.06 or 0.12 m/s** *(If this cannot be achieved with current screen at required flow)*	☐
3	Sweep velocity	Greater than approach - significant	☐	Moderate	☐	No or Negligible	☐
	Screen angle	between 0º and 45º	☐			between 45º and 90º relative to flow direction)	☐
4	Bypass – entrance location	Inline with from of screen	☐	Upstream of screen	☐		
	Bypass - sweep	Good sweep velocity to bypass	☐			No sweep velocity to bypass	☐
	Bypass - flow	Bypass flow > 10% of intake flow	☐	Bypass flow < 10% of intake flow	☐		
	Bypass – entrance type	Open channel	☐	pipe	☐		
	Bypass distance	< 200 metres	☐			• > 200 metres	☐
5	Bypass – connectivity adequate	Yes	☐	No	☐		
6	Screen – aperture size	< 3mm for holes, < 2mm slot width, or < 2mm with 2km of coast.	☐	> 3mm for holes, > 2mm slot width, or > 2mm with 2km of coast. (where aperture size can be confirmed and modified	☐	> 3mm for holes, > 2mm slot width, or > 2mm with 2km of coast. *(novel screen where aperture size cannot be confirmed or modified)*	☐
	Screen – condition	• Effective	☐	Ineffective minor / significant	☐		
	Screen – blockage risk	• Effective	☐	Moderate	☐	Significant	☐
	Screen - seals	• Effective	☐	Ineffective – minor / significant	☐		
7	Operation & Maintenance	Effective	☐	Ineffective – minor/significant	☐		

Assessment of effects associated with Alliance's diversion and proposed monitoring methodology

23. An assessment of the effects associated with Alliance diversion and proposed monitoring methodology needs to consider the following issues:

    a. The possibility of fish entrainment in the intake channel;

    b. The possibility of fish impingement on the trash screen; and

    c. The possibility of fish injury / mortality.

Entrainment

24. To assess the possibility for entrainment of fish in Alliance's intake channel it is necessary to consider what fish species are likely to reside in or pass through the vicinity of the intake and their probability of entering the intake channel. In this case,

it has been agreed by the freshwater ecology witnesses that the following fish species are present in the area around the Mataura Falls and will pass through the area moving downstream:

a. Eels (short and long fin);

b. Brown trout (juvenile and adults),

c. Lamprey; and

d. Koaro.[4]

In addition, it was agreed that:

a. Other native species may be carried through this area; and

b. While arguably not obligate, the lower brown trout river fishery is likely supported by the downward migration of juvenile fish given the more abundant spawning habitat in tributaries above the falls.[5]

25. It is generally accepted that the proportion of fish lost to unscreened (or poorly screened) water intakes is at least proportional to the flow diverted from the river (Glova and Boubee, 2002; Unwin et al., 2005. On this basis it can be expected that under median to low flow conditions between 17 – 54% of fish passing by would enter the Alliance intake.[6] In this regard, I note the comments by Hay (2018) that estimates of direct proportionality may represent worst case scenario. In response, I consider that:

a. Given the relatively shallow depth of flow over the weir (the minimum 50mm depth at the centre of the existing weir on the Mataura River due to the exercise of Alliance and Mataura Industrial Estates current consents is equivalent to a flow of 2.6m^3/s over the Mataura Falls) compared with the depth of Alliance's intake channel (approximately 2m deep by 7m wide), the proportion of fish diverted may be higher, especially for juvenile brown trout, if they are following the deeper bank side channel. In this regard:

i. Downstream migrating salmon and trout fry display positive rheotaxis (orient themselves head into the current); and

ii. Salmon and trout fry have a strong preference for bank side movement and keep to the edges of the main channels, near to the banks of streams and rivers (Unwin, (1986); Hopkins and Unwin, (1987), Fox et al., (2003); Unwin and Taylor, (2007)), which would therefore mean they would be near to any water intake located near the river bank.

b. The issue of exactly what proportion of fish, including their species and age class, passing by are diverted into the Alliance intake is currently unknown.

[4] Joint ecological witnesses conferencing statement of 15 November 2018 – 'Downstream' at page 2.
[5] Ibid.
[6] Assuming a 10m^3/s water take by Alliance from the main stem and the following flow statistics at Tuturau: median flow – 57.8m^3/s and 7-day MALF – 18.47m^3/s. https://envdata.es.govt.nz/index.aspx - accessed 23 November 2018

26. Fish mortality due to turbines is well documented; as have results from impact (or 'strike'), pressure changes associated with passing through high, then low pressure zones) and high shear stress (close to fixed and moving surfaces and in the turbulent wake of the blade and in the draft tube (Turnpenny et al. (2000)).

27. Alliance have provided a table of predicted mortality associated with entrainment in the intake and passing through the Francis turbine.[7] In response, I do not consider that 'mortality' percentages are likely to be as precise as described by Alliance. Literature on the subject, such as DWA (2005), provides that fish mortality caused by turbine passage is dependent on the fish species and their length, as well as the turbine type and dimension, the head and the individual operational conditions. Consequently, mortality rates during turbine passage are likely to vary depending upon variables, such as flow and turbine speed. What is clear, however, is that passage through Alliance's existing Francis turbine is likely to result in mortality for some fish, particularly for larger individuals, including adult brown trout.

Fish swimming ability

28. The swimming ability of a fish is a primary consideration in relation in designing any fish screen. In my opinion, it is also a primary consideration in relation to the design of the proposed monitoring programme and the potential effects of it.

29. Environmental variables such as water temperature, dissolved oxygen levels, fish size, stage of development and fish health are all significant factors affecting fish swimming ability (Norland, (1996)).

30. There have been many studies and reviews of fish swimming abilities and performance. Fish swimming speeds have been categorised based on the ability of the fish to maintain a particular speed before muscle fatigue occurs (Jamieson et al (2007) and Norland, (1996)): burst (or darting) speed and sustained (or cruising) speed.

31. *Burst* speed is a survival response used for moving away from situations such as predators or ascending riffles. In a burst swimming mode, the fish utilises large volumes of white muscle tissue, which has poor blood supply and only provides high power for a very short time period (Jamieson et al (2007)). It requires high energy exertion and is used infrequently. Fish can take many hours (up to 24 hours) to recover from burst speed related exhaustion.

32. In a *sustained* swimming mode, the fish utilises small volumes of red muscle tissue that have good blood supply – so that these low power muscles can be used to propel the fish for long periods of time without oxygen deficit or lactic acid build up (Jamieson et al (2007)). The sustained speed can be maintained for long periods of time and is used for routine movement, such as foraging.

33. For avoiding or escaping entrainment and / or impingement it is the sustained swimming ability that is critical. Jamieson et al (2007) consider that several factors about sustained swimming ability need to be considered:

   a. The most significant factor affecting a fish's sustained swimming ability is its size because smaller fish are not capable of swimming as fast as larger fish;

[7] See Table 3 at page of Golder 2016.

b. Different species of fish have different swimming abilities, and those roughly correspond to general features such as body length and swimming action. Swimming ability also vary through fish life stage; and

c. Water temperature affects swimming performance, and sustained swimming speeds may decrease significantly at extremely high or low temperatures.

34. Jamieson et al (2007) suggest the following general rule of thumb as the most appropriate method of determining maximum approach velocity, namely **approach velocity should not exceed four times the body length of the smallest fish present per second**. This formula is widely accepted in relation to several salmonid fish species, including brown trout.

Approach velocity

35. As discussed, approach velocity refers to the velocity of approaching water. Approach velocity is important for the safety and survival of fish because in order to escape from a physical barrier, such as the trash screen, any fish entering the intake channel needs to be able to swim upstream against the water flow for a sustained period. If the approach velocity exceeds the fishes sustained swimming ability, then the fish will become exhausted and be impinged on the trash screen if it cannot pass through.

36. Evidence of Doyle Richardson on behalf of Alliance provides that the intake channel is approximately 375m long and 7m wide at the entrance, reducing to 4m wide immediately upstream of the trash screen. According to Boubee (2018b) the intake channel is approximately 2m deep. For a $10m^3/s$ abstraction this translates to:

a. An average water velocity of approximately 0.7m/s at the intake entrance; [8] and

b. An average water velocity of approximately 1.25m/s immediately upstream of the trash screen. This is, however, a conservative estimate that does not take account of the cumulative thickness of the incumbent bars on the trash screen, which will reduce the effective cross-sectional area.[9]

In my experience water movement even in a straight intake channel is not uniform resulting in inconsistent and uneven water velocities near screen faces. Bed and wall friction tend to reduce marginal velocities and increase the velocities in the mid channel and near the water surface (Turnpenny et al. (1998)). In this case, no measurements have been undertaken by Alliance in relation to water velocity approaching the trash screen nor does it constitute part of the proposed monitoring programme. I consider that this is problematic insofar as approach velocity is likely to have a significant impact upon the potential for fish entrainment in the intake channel and impingement on the trash screen, which is likely to influence injury and mortality of impinged fish.

37. Based on the methodology presented by Jamieson et al (2007) the above water velocities are within the sustained swimming ability of brown trout greater than 175mm at the entrance to the intake (0.7m/s), assuming they react quickly enough

[8] Methodology – Flow rate ÷ cross sectional intake area = average water velocity, i.e. 10 ÷ 14 (7 x 2) = 0.7m/s.

[9] Methodology – Flow rate ÷ cross sectional intake area = average water velocity, i.e. 10 ÷ 8 (4 x 2) = 1.25m/s.

before moving far down the channel, and greater than 312.5mm at the trash screen. As such, while brown trout larger than 312.5mm may be able to make headway up the intake channel from in the vicinity of the trash screen and back to the mainstem of the Mataura River, smaller brown trout probably cannot unless they react quickly before moving far down the channel.

Sweep velocity and fish bypass at screen

38. As discussed, sweep velocity is the term used to describe the velocity of water across a screen, at right angles to the approach velocity. The angle of the screen to the flow determines this component of water velocity. Lower angles of screen to the flow ensure higher sweep velocity and shorter exposure of fish to the screen. The successful guidance of fish to an escape route at the screen depends upon this component of water velocity, which should carry fish away from the screen and back to the main flow / channel either directly or via a bypass.

39. The objective of a fish bypass is to safely transport fish away from a screen back into the main flow, rather than being impinged on a screen or penetrating the screen and getting into a turbine or irrigation supply. Jamieson et al (2007) provides that the general requirements of a bypass are:

    a. Entrances should be easily located by fish and be flush with or close to the screen. A bypass should work in tandem with the sweep velocity across the screen – fish should be swept across and away from the screen and into a bypass.

    b. Bypass entrances should extend from the base of the intake channel to the water surface, i.e. be a slot rather than a pipe;

    c. The flow velocity should draw the fish into the bypass entrance and there should be enough flow into and through the bypass to prevent fish returning; and

    d. Once a fish has been diverted from a screen and entered a bypass it should then be delivered safely back to the source river. To ensure this:

        i. The interior of the bypass should pose no risks to fish travelling through, so that extreme bends, obstacles, rough surfaces, jumps and free-falls should be avoided; and

        ii. The bypass outfall, where water and fish from the bypass re-join the main flow downstream from the screen intake, should not pose risks to the fish. For example, fish should not be exposed to excessive free fall, or impact onto hard surfaces and / or shallow water. The bypass outfall should also return fish to active water and generally avoid returning fish to the mainstem in such a way as to expose the fish to predation from other (larger) fish or birds.

40. I make the following observations in relation to the location of the trash screen, sweep velocity and lack of an effective escape route:

    a. The trash screen is not positioned flush with the banks of the river at the very beginning of the intake channel to avoid diverting fish out of the main channel of the river. Instead it is located perpendicular to the flow on the intake channel approximately 375m downstream;

b. The trash screen is set at 90°, i.e. perpendicular, to the flow of the approaching water;

c. There is no effective escape route or bypass that can be used by fish entrained in the intake channel or impinged on the fish screen to safely return to the mainstem of the Mataura River; and

d. There is no sweep velocity component, i.e. all flow in the intake channel at the screen face goes through it. This point is, however, largely academic given that there is no effective escape route or bypass in place to allow fish to return safely to the mainstem of the Mataura River.

In my opinion, the perpendicular placement of the trash screen at the end of the 375m intake channel with no effective escape route is likely to serve as a trap for fish that cannot avoid entrainment and subsequent impingement on it. For the avoidance of doubt, the proposed amendments to the bar gap on the trash screen do not constitute effective fish screening, which as discussed requires seven factors to be addressed in combination, i.e. it is not one or the other.

Bar gap spacing

41. I understand that Alliance proposes to annually reduce the bar gap on the trash screen during the 5-year monitoring period over the period February to May (inclusive) from 60mm to 20mm. It is unclear to me whether during the period June – January (inclusive) the bar gap will be maintained at 20mm or reinstated to the original 60mm. In any event, it is important to consider what size fish the modified trash screen bar gaps of 20mm and 60mm are likely to physically exclude and the consequences of doing this.

42. Research (DWA, (2005)) suggests that the maximum fish screen bar gap to exclude brown trout should be 10% of the fish's length.[10] On this basis:

a. A 20mm bar gap would be expected to exclude brown trout greater than 200mm in length, i.e. brown trout less than 200m would be expected to be able to physically pass through the modified trash screen.

I do, however, consider that this is likely that brown trout smaller than 200mm could still become impinged on the modified trash screen with 20mm bar gaps. In my experience, when salmonids come up against an instream barrier, such as a fish screen, they frequently orientate themselves head into the current as they endeavour to move away from the structure. This can result in them being perpendicularly impinged on a screen, especially when the approach velocity exceeds the sustained swimming speed of an individual fish. As discussed, sustained swimming speed is dependent upon the size of an individual fish.

b. A 60mm bar gap would be expected to exclude brown trout greater than 600mm in length, i.e. brown trout less than 600mm would be expected to be able to physically pass through the screen. Again, this is likely to be a conservative estimate, particularly if the approach velocity exceeds the sustained swimming speed of an individual fish.

[10] See Table 5.2: Relevant body dimensions and proportions of fish of different body shapes.

I note Mr Moss' evidence that otolith analysis demonstrates brown trout in the lower Mataura River (below Gore) do not grow beyond 550mm irrespective of age. Since there is no fish bypass to safely return fish entrained in the intake channel, all brown trout in the lower Mataura River, including adults and all juveniles, could be expected to able to physically pass through the trash screen with 60mm bar gaps and enter the turbine. Whether this in fact happens is depend upon the sustained swimming ability of an individual fish.

43. It is important to recognise that reducing the bar gaps on the trash screen will increase water velocity through the screen as a result of reducing the cross-sectional area conveying flow due to the cumulative thickness of the screen bars as described by Boubee (2018b) and Hay (2018). In my opinion, this is likely to exacerbate the issues in relation to entrainment and / or impingement, particularly for brown trout that may have been able to maintain a sustained swimming speed in excess of 1.2m/s. Ultimately the extent of this effect depends on the increase in approach velocity.

44. In this case, Boubee (2018b) estimates that modification to the trash screen will cause the through screen velocity to increase from an estimated 1.4m/s to 1.8m/s at high flows. Application of the formula in Jamieson et al (2007) shows that increases in approach velocities at the front of the trash screen will result in entrainment and impingement of the following size brown trout at the following flows: 1.3m/s – 325mm, 1.4m/s – 350mm, 1.5m/s – 375mm, 1.6m/s – 400mm, 1.7m/s - 425, 1.8m/s – 450mm. The effect of this is that based upon the sustained swimming speed of adult brown trout at a flow of 1.8m/s only those individuals greater than 450mm are likely to avoid entrainment and impingement at the face of the trash screen.

Impingement and fish mortality

45. I understand accumulated wood vegetation, such as sticks, are removed from the trash screen by a horizontal bar with protruding rakes that is periodically drawn up the face of the screen by a chain drive mechanism on either side. Alliance proposes to use the existing 'stick' bar / rake to remove impinged adult eels and other fish and to modify the existing trash sluice to retain those fish for physical handling and potential release.

46. In my opinion, rates of mortality for brown trout as a result of the proposed methodology are likely to be significantly influenced by:

    a. The approach velocity at the face of the trash screen;

    b. The length of time that fish are impinged on the trash screen;

    c. The extent of any injuries associated with impingement on the trash screen and subsequent travel up the face of it, including the effect of being dropped into the sluice along with wood vegetation;

    d. The length of time that fish are held in the sluice; and

    e. How fish are physically handled prior to release.

I agree with Zane Moss that mortality rates for impinged and captured brown trout are likely to be high unless they are rapidly removed into a cool, well oxygenated, holding tank and appropriately handled prior to release to the mainstem of the lower Mataura River.

Proposed monitoring programme

47. I acknowledge that the proposed monitoring programme will provide information about eels and brown trout that are impinged and successfully captured, insofar as they can be physically handled and weighed / measured etc. However, this is contingent upon Alliance being able to physically modify the existing trash screen, it being fit for purpose and a high degree of intervention by suitably trained staff.

48. A significant limitation of the proposed monitoring methodology is that any conclusions about the downstream migration potential in the lower Mataura River or mortality / damage rates can only be taken from fish that are entrained, physically impinged on the modified trash screen and subsequently captured either alive or dead. Consequently, the proposed monitoring programme:

    a. Will not provide any information on the proportion of fish, including species and age classes, that are diverted from the main mainstem and entrained in the intake channel, which is likely to vary with flow and seasonality. As discussed, a common assumption in the absence of any other information is that the number of fishes entrained into an unscreened water intake is directly proportional to the amount of flow diverted to the take.

    b. Will be biased toward larger fish. In this case, it is likely to miss brown trout that are smaller than 200mm, which are likely to pass through the trash screen and turbine undetected;

    c. Is limited to the downstream eel migration period (January – May inclusive). As such, it will not provide any information on numbers of fish being entrained and impinged at other times of the year, i.e. from June – December inclusive; and

    d. It will provide no information on the fate of fish, including brown trout, that pass through the trash screen and turbine.

49. Hay (2018) considers that the proposed monitoring could be augmented as follows:

    a. Extension of PIT tagging to include brown trout upstream of the intake, which would provide some understanding of the proportion of brown trout being diverted from the mainstem of the Mataura River into the intake channel;

    b. Use of DIDSON in the intake channel, which would provide some understanding of numbers of fish entering the intake and passing through the trash screen and turbine; and

    c. Monitoring of the fate of fish that physically pass through the trash screen and turbine.

    I agree that each of the above monitoring approaches has the potential to provide useful information on different facets of fish entrainment and turbine passage at the Alliance hydro plant. Employing these approaches would produce a more complete understanding of the effects of the activity and how it can best be mitigated.

50. In my opinion, the proposed monitoring represents a worse outcome for brown trout than the status quo during the monitoring period. This is because reducing the bar

gaps on the trash screen from 60mm to 20mm is likely to have a two-fold effect, namely by:

a. Increasing the through screen velocity, which as described is likely to increase the rates of impingement and associated injury / mortality; and

b. Capturing brown trout between 200 – 450mm in length that currently have a chance of passing through the existing trash screen and turbine with some chance of survival, albeit dependent on their body length. Alliance's estimates provide predicted mortality is 25.7% for 200mm fish, 37.5% for 300mm fish, 49.3% for 400mm fish and 61.1% for 500mm fish.

As discussed in the evidence of Zane Moss for Fish & Game:

a. Mortality of any impinged brown trout that are successfully captured (assuming they are removed from the trash screen in a timely and uninjured state) is likely to be high unless they are rapidly placed in cool well oxygenated river water and handling stress is minimised; and

b. The monitoring methodology is likely to underestimate the mortality rates of fish impinged on the trash screen unless they are subsequently held and observed for approximately 24hours to determine whether they are suitable for release.

51. Further to the above comments, I anticipate difficulties with physically implementing the proposed monitoring. For example:

a. Reducing the bar gaps on the trash screen is likely to result in the capture of more vegetation that will need to be dealt with and as discussed, the creation of higher approach velocities at the screen face.

b. In order to physically withdraw fish impinged up the face of the modified trash screen troughs or channels will need to be mounted on the horizontal stick rake, which is chain driven. Whether this can be done without high probability of grinding injuries as captured fish are carried up the face of the trash screen is currently untested. In any event, sealing of the travelling stick rake mechanism against the bottom of the channel is likely to difficult if troughs need to be installed on it.

I consider that troughs will be needed to be installed on the stick rake mechanism to successfully transport live fish up the face of the trash screen. Any troughs would need to be of sufficient depth and width to accommodate large eels and adult trout that are either laying on their side or upright. An adult brown trout measuring 550mm long will be approximately 9cm in height (approximately 17% of body length) and 5.5cm wide (approximately 10% of body length) (DWA (2005)). As such, troughs would need to be at least 10+cm wide at the both the narrowest and lowest points to accommodate the possibility of a 550mm adult brown trout laying on either upright or on its side.

c. If the methodology is to be effective for monitoring it will need to continuously operated and maintained by appropriately trained staff.

Proposed consent conditions

52. I have considered the draft consent conditions attached to the evidence of John Kyle on behalf of Alliance and attached to the s 42A report prepared by Stephen West on behalf of Environment Southland. In response:

a. I am concerned about the lack of performance objectives in both sets of consent conditions in relation to the gathering of information about fish species other than downstream migrating adult eels, notwithstanding that Alliance's diversion and take will be having effects on other fish species, including brown trout.

b. I note that the draft consent conditions attached to the evidence of John Kyle for Alliance refers to:

"Modifications required to the trash screen bar size so as to not be greater than 30mm".[11]

I take this to be a reference to bar gap size rather than size of the bars and note that Boubee (2018b) recommends 20mm bar gaps and the that evidence of Mark James for Alliance refers to 20mm bar gaps[12]. This point requires clarification because bar gap size will have an influence on the size of fish that can be expected to be impinged on the modified trash screen and the size of fish that can be expected to pass through the modified trash screen and enter the turbine. As discussed, a 20mm bar gap can be expected to impinge brown trout greater than 200mm and a 30mm bar gap can be expected to impinge brown trout greater than 300mm.

c. The draft consent conditions attached to the s 42A report by Stephen West on behalf of Environment Southland provide for:

i. "Recording of the number, size and species of eels" – Condition 8(c)(v); and

ii. "Recording of, <u>as far as practicable</u>, the number, size and species of other fish" – Condition 8(c)(vi) (emphasis added)

In response, I am not sure why from an ecological point of view Mr West has inserted the caveat "as far as practicable" in relation to the gathering of information regarding recording of the number, size and species of "other fish", which presumably includes brown trout.

d. Neither of the above sets of draft consent conditions expressly provide for Alliance to implement effective fish screening if an adverse effect on downstream migrating eels and / or other fish, including brown trout, is detected as a result of the monitoring programme. In this regard, the draft conditions attached to the evidence of John Kyle only requires Alliance to take steps to mitigate the effects of its activity if monitoring *". . identifies a significant adverse effect on downstream eel passage . . ."*[13], i.e. Alliance is not expressly required to take any steps if a significant adverse effect is detected on fish species other than eels moving downstream.

[11] See condition 14(b).
[12] Evidence-in-chief of Mark James (dated 21 November 2018) – paragraph 37.
[13] See conditions 21 and 22.

I consider that consent conditions should be specific and prescribe design criteria for fish screening in line with current best practice if an adverse effect is detected on eels and other fish, including brown trout.

Recommended criteria for the design of an effective fish screen for sports fish

53. The following fish screen criteria are recommended to protect brown trout, including juvenile brown trout, in the lower Mataura River:

    a. Fish screen at the point of water diversion from the mainstem (or as close as practical) – screen angle relative to direction of water flow does not exceed 45°;

    b. Maximum approach water velocity of 0.12m/s;

    c. Sweep velocity parallel to the face of the screen that is equal or greater than approach velocity;

    d. Maximum screen material opening size:

        i. 2mm for profile bar screens;

        ii. 3mm for woven mesh screens; and

        iii. 3.2mm for perforated plate screens (round openings);

    e. Effective bypass system ensuring fish return undamaged to the mainstem of the Mataura River; and

    f. Effective maintenance and operation of the scheme.

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Tony Hawker

Date: Wednesday, 28 November 2018

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