TANK Collaborative Stakeholder Group

Meeting Twenty-Five - Record

When: Tuesday, 13 December 2016, 9:30am – 4:30pm

Where: Ellwood Function Centre, Hastings

- Note: this meeting record is not minutes per se. It is not intended to capture everything that was said; rather it is a summary of the proceedings with key comments noted. *Text in italics indicates a response from HBRC to questions posed during the meeting.*
- *Where additional information has become available subsequent to the meeting (such as answers to questions unable to be answered in the meeting), this is included in red italics [as up to 30 January 2016].*

Meeting Objectives (slide 5)

Karamu

1. Understand the current state of surface water quality in the Karamū and impact on values
2. Confirm Karamū values and attributes
3. Agree desired attributes state options for modelling purposes
4. Consider draft Karamū management solutions

Water quantity

5. Understand what the groundwater/surface water model can do and can't do
6. Agree further scenarios to be modelled and reported back.

AGENDA ITEMS

1. Welcome and karakia

Robyn welcomed everybody and everyone said a karakia together.

2. Agenda, early discussion and introductions

- Housekeeping matters covered.
- Apologies were confirmed.
- Meeting being recorded but will not be available publicly. It is recorded for the purpose of assisting in compiling the minutes.
- The meeting agenda and objectives were outlined.
- Ground rules for observers confirmed.
- Engagement etiquette was covered.
- Open floor for TANK members for notices and announcements
    - Vaughan thanked Desiree for organising the jet boat trip. It was very enjoyable but noted that for health and safety reasons members who made alternative return trip arrangements should have made it known.
    - Jim announced that the VMO research programme has ended but they have funds to repeat the TANK member survey in early January 2017 (previous survey was July 2015) and will also be looking to survey the community's understanding of the TANK process later in 2017.
- Lochie MacGillivray, Richard Pentreath From AgFirst and Brian Bell from Nimmo-Bell were introduced as part of the team doing the socio-economic assessment. AgFirst will build the on-farm model budgets, which are still in the conceptual stage. The farm budgets will then feed into the regional economic model to be developed by Nimmo-Bell as well as Market Economics. The regional input-output model will determine the in/direct economic benefits and costs under different policy settings. Further information on the methodology underpinning the farm models will be presented to TANK for input/approval.

3. Item # 1 – Meeting Record 24 (slides 8 - 10)

The details for the sediment item (# 5) are being finalised.

One query was raised as to the accuracy of the numbers in paragraph 5 on page 4 in relation to sources of groundwater recharge are accurate. This is important because there are different influences on the aquifer and the TANK Group will be setting limits and numbers at a later stage in the plan process. *Some more accurate numbers will be presented this afternoon*.

[post meeting note; further information about groundwater takes also to be presented at meeting 26]

Clarification was sought on Action point 24.10 - changes to the Hastings District Plan.

- Mark Clews explained that there are two matters being addressed at this time, Omahu Road and Irongate, through HDC Plan review. There is an unconfined aquifer resource management unit rule that overlays a number of different zones (i.e. industrial). The reviewed plan changes this to put rules in the individual zones and in other parts of the plan. They were not removed, rather reshuffled and to provide more clarity on how they apply. There are currently submissions and appeals against the proposed plan.
- This is related to aquifer management. Concerns have been raised about the HDC plan review and protection of the aquifer. This needs to been connected into the TANK process. A request was made to ensure Nick Jones is involved with discussions about management of urban development.

[post meeting note – this will be achieved through Nick's involvement with the Stormwater Working Group]

Action items	
25.2	Circulate Item 5 on sediment before the next TANK meeting on 9th February 2017.

4. Item # 2 – Karamu Catchment Values

A summary of the Karamu Catchment Values was presented with amendments suggested by the TANK Group prior to the meeting (slide 13). The conversation about these values will continue offline and be further refined.

5. Item # 3 – Karamu Catchment Water Quality and Ecology

Sandy presented the water quality data for the Karamu in relation to NOF attributes contact recreation/health (*E.* coli) and nitrate and ammonia toxicity, and other attributes trophic state (algae and aquatic plants), nutrients (DIN, TN, DRP and TP), clarity and ecosystem health (MCI). A description of the water quality and ecosystem state was provided by Sandy along with a description of the implications and drivers for the current state and the implications for the Waitangi Estuary. This is summarised in attachment 1.1

Sandy advised the group that additional advice had been sought from aquatic ecology scientists about possible management options to improve the Karamu ecosystems. Their report has been received by council in draft – and would be circulated to the TANK Group when complete. However, their draft recommendations were presented.

<u>Matters raised by the TANK Group</u>:

Targeted study:

- The data is reporting bad ecosystem health across the attributes. Are the phosphorus levels worse objectively than nitrogen? Is phosphorus the number one priority for nutrients?
  Yes phosphorus is the higher priority nutrient.
- Is the table the same as the MCI report put in Dropbox prior to the meeting or is it different?
  It is a different table because they are different sites. The sites in the slide are just the SOE sites. The report in Dropbox is the targeted study report with more sites and also some outside the Karamu catchment to provide a comparison.
- How well do the sample sites correlate to recreational use? The Karewarewa Stream at Turamoe Road has been included in the information presented but the Karewarewa Stream at Raukawa Road is often used as a swimming hole and that is not included. The Karewarewa Stream goes dry so how does that impact on the MCI and that is not represented?
  The targeted study was to look at ecosystem health so we did not really look at sites that are used for recreation. The sites at Turamoe Road and Pakipaki Bridge are SOE sites with long-term data which is useful. The targeted study was a snapshot in time and all of the sites monitored were flowing at that time.
- How many samples sites were there for each waterway? Are you limited by budget? There does not seem to be many. When you are talking about downstream of a point source, how far downstream? Wouldn't it be a good idea to compare pre and post discharge water quality?
  In the NOF guidelines for dissolved oxygen we only have guidelines for point source discharges. But these NOF thresholds for the impact of low dissolved oxygen on stream health can also be used as a guidance in low DO-impacted streams that do not have a point source discharge. We do not have any identified point source discharges that lower dissolved oxygen in the Karamu Stream. This targeted investigation was about identifying the stressors that are triggering the low MCI. It was not about comparing upstream with downstream. The investigation looked into the difference in ecosystem health and MCI across the Karamu catchment and outside the catchment trying to capture a gradient between good and bad. Budget and staff time was limited but there were enough sites sampled to assess correlations.
- Were there just oneoff samples used or 3-4?
  One-off samples were used to keep the samples all in the same week and enable correlations.
- With oxygen from the air, is the flow and the riffles taken into account in the assessment?
  Yes. Water velocity was also measured. Water velocity did not correlate as well with MCI as oxygen and temperature.
- When there is an excess of algal growth that takes a lot of oxygen out of the water, does it (go out of) balance so that after a certain amount (of time) the positive output of oxygen from the plants doesn't outweigh it during the night?
  Yes.
- Are there plants that use more oxygen than others?
  There is not much knowledge on species specific oxygen production and demand for aquatic plants. While it is likely to be different between species and also life stages, it is important how much plant material is actively exchanging oxygen in the stream channel - and taking out oxygen at night time when the plants respire. But we also have to keep in mind that in soft sediment streams the plants provide valuable habitat for bugs and fish. A threshold of ca 30% volume of macrophytes (a third of the stream) has been suggested by some experts as a good balance where the plants provide habitat, and may cause a dip in oxygen overnight but without taking too much oxygen out of the stream. (NB:

apart from the impact on dissolved oxygen there are also some exotic aquatic plants to watch out for because they are very invasive).

Waterway values and management options/factors following targeted study:

- An action point from the last meeting was to put the ecological health strand underneath the economic assessment group. How do you reconcile the requirements of an ecosystem for health purposes when it sits under the economics assessment? Does the economics come before the ecosystem requirements?
  First we need to identify what the problems are and what the potential solutions are, then cost out those solutions and see whether they are affordable or how long it takes. It will be an iterative process trying to work out what ecosystem health you are looking for, what management objectives you want to aim for and what that means in terms of the mitigation measures to be adopted. If the management options to get the desired state are not affordable, the management options might be adjusted. Or instead it might be a matter of the time it will take. It is something still to be negotiated.
- If you are going to make decision based on cost, I'd go with the timelines because if it is law or these are policy then you have to opt down the time pathway. It is not a matter of whether it is too expensive if this is law or the values of the group. I don't want the aspirations of this TANK Group to be pre-empted by considering it unaffordable.
  It will probably be a trade-off around how long it takes because the shorter the time the more expensive the investment is in the short term. With more time, the costs can be spread out. This issue is falling under the economics group so that we can work out what the costs would be. But working out what the costs would be is not the same as putting economic values ahead of ecological values. It is just gathering information so that we can make an informed decision later on. There are different management options for the group to work through.
- The economics group should consider it but the decision should sit with the TANK plenary group. *Agreed.*
- Did the targeted study include the Clive/Ngaruroro mainstem?
  No. The targeted study was carried out only for the Karamu Stream tributaries. The study had to stay within the range to provide for the statistical analysis so the mainstem data was not included.
- In comparing the Te Waikaha Stream to the Awanui Stream (slide 28), is it fair to comment that one has cover and the other is completely open which will be affecting both temperature and oxygen levels?
  Yes and this is the problem in these open streams. The streams have to be shaded to lower the water temperature.
- Is temperature only driven by shade? Flow would be a contributing factor but in terms of addressing the problem would the solution be overwhelmingly shading rather than augmenting flow?
  Water coming from springs and groundwater contributions to a river are naturally cool. Flowing downstream, shading protects the water from heating up too much in summer, therefore shading is a big factor in terms of insulating the water body from heating up too much. Especially when you look at the small streams which adjust towards the air temperature in summer very quickly: A small volume of water and shallow water levels lead to rapid temperature exchanges between air and water. The small streams affect higher order streams when the tributaries come together, so while small streams may not seem important, they have a significant downstream effect in their sum. If small steams in upper catchments are not shaded at all, the larger receiving streams get too warm in summer. Groundwater input to flow can be helpful to cool temperatures and this can be observed in the Irongate and Raupare Streams for example. Where there is no groundwater input and in small streams, shading is key to addressing the problem.

Drains versus rivers/streams

A key matter for the TANK Group was around what is considered a "drain" and what is considered a waterway/stream, and what "drains" have to be managed for.

A lengthy discussion at this point and also later during the meeting in relation to the recommendations for further action on this matter included the following questions and observations;

- The main purpose that many of the Karamu network watercourses were constructed (or modified) was drainage and flood control.
- Do we have to maintain ecosystem health and macroinvertebrate health in a drain or roadside water table if its sole purpose is drainage?
- What objectives should be applied to things like MCI in drains compared to in rivers?
- Different management methods could be trialled in drains to find out if it makes any difference.
- The drainage capacity of a waterway is a value.
- What is natural water – does it include underground water?
- What does it mean to manage water quality in drains?
- Would another way to view it be that the drain use to be a traditional stream that has been made into a drain as well?
- What is a drain to one person might be a waterway to another.
- Giving names to waterways is an indication of its value (e.g. the Awanui and Waikaha)
- An example was given about managing discharges and the need to understand the connectivity – (e.g. paint discharged into a gutter ended up in a stream)
- Would it be reasonable to assume that the standards for ecosystem health might be different for the Awanui as opposed to the Waitio?
- How watercourses are defined is an important issue. Is it relevant to today's discussion or are we picking it up somewhere else?
- It was suggested that every waterway marked as a blue line on a LINZ map should be considered a stream because LINZ don't put drains on maps.
- The management objectives need to recognise that the drainage function of streams is very important. The simple way to resolve this is to maintain the drainage capacity of the waterway as part of the scheme.
- The mapping of rivers and drains, including historical flow paths was considered by some to be very important in informing how rivers and watercourses have changed over time and to help us to accept where we are at today. This affects the changing definitions, which will change again in time.

Some response by staff was provided, including the following responses;

- *Clarification about management of drains and rivers is relevant to discussion about river management in TANK catchments*
- *Drains contain water and we therefore have to manage them for water quality and ecology impacts as well.*
- *If the water is not in a pipe, cistern or tank, we have to manage the water.*
- *A waterway is either a river, modified watercourse or a drain that diverts and discharges ground and/or surface water.*
- *The watercourses and drains in the Karamu have multiple objectives, values and functions and this has to be recognised. The group has to decide in what direction these waterways will be managed, i.e. drainage and flooding function or can we look at a different way of managing these systems to meet multiple objectives including for the ecosystem.*
- *This is an issue across NZ and there is developing case law to help make distinctions.*

- *Further information to come from Gary about the extent to which the system provides for drainage and flooding and how we might be able to improve ecosystems within these constraints.*
- *Further information for the group about the definition of ditches, drains and rivers is still required.*

Action Item	
25.3	Further information about what a drain, ditch and river means and what implications this has for deciding on objectives and management responses.

Other Matters

- The NOF attributes are compulsory. Will there be more NOF attributes?
  There are likely to be more NOF attributes coming in but some attributes will not come in under the NOF, they will be left to be addressed at a regional level.
- Can you provide us with an example of how oxygen works with point source versus non-point source discharges?
  Dissolved oxygen levels above a discharge point from an oxidation pond or a high organic load will be higher than they are below the point discharge because oxygen is used up in the process of breaking down the discharged material. Knowing the source of the problem allows you to manage the cause of oxygen depletion. In the Karamu catchment we do not know of any point sources causing oxygen depletion but the system still has very low oxygen. So we looked into the cause of the low dissolved oxygen problem and what can be done about it because it may have different reasons.
- When the weed boat is used to cut out the weed in the stream, when that weed breaks down does it take a lot of oxygen out of the stream? Is it beneficial to cut the weed and let if float downstream?
  It depends on where the cut weed ends up, whether it spreads out or accumulates in one zone. If the weed builds up in one place there will be localised oxygen depletion when the plants breakdown.
- Is the cut weed also a potential source of *E. coli*?
  Yes.

6. Item # 4 – Minimum Flows for the Heretaunga Plains

The goal today was not to set minimum flows but to narrow down some options. We cannot provide potential economic consequences until we have some options to investigate. Thomas recapped on direction from previous meetings and preliminary targets and provided some background information. In the Karamu Stream catchment, oxygen is a more critical issue than depth and velocity. His presentation is summarised in Attachment 1.2

Matters raised by the TANK Group:

- In relation to the statement that oxygen levels can drop to zero in the Awanui Stream and stay at that level for long periods of time, how long?
  During the 2013 drought there was no oxygen in the stream every morning for 77 days.
- How can you have more than 100% oxygen saturation?
  Because the plants are producing. If you mix the water to the point where it is in equilibrium with the air, saturation is at 100%. If the plants are diffusing oxygen from the leaves into the water, they can push the saturation over 100%.
- What was the monitoring time period (slide 59)? Has the monitoring been ad hoc or at a certain time of the day or year?
  HBRC has been monitoring oxygen levels at the sites for several years and HBRC has developed hydraulic models for those streams based on surveys in 2013. The oxygen level is measured every 5

– 15 minutes. The graph for Awanui Stream shows every data point over a one year period (slide 57) and HBRC is still monitoring it. We are capturing real time data for the sites in the intensive investigation. For the other sites, 40 streams, we go out and survey them all in one morning in the same conditions.

- Are there seasonal fluctuations between winter and summer? Is that graph what you would expect from winter to summer?
  Yes. You can see in winter it converges around the 70 – 80% oxygen in June – July and that range gets wider as you go into summer.
- Bearing in mind that the 2013 drought was a 1 in 100 year drought, shouldn't we calibrate the findings in that year to other years so that we don't take the data from that year?
  We should definitely calibrate to 2013 because this is when the stress is on, this is the type of year when the competition between irrigation and instream uses is the highest so it is critical to use those low flow conditions and calibrate the model to enable prediction of how low levels can get as well as high levels. We need to cover and calibrate over the range of conditions. We are able to do this because of the 2013 drought. Often we miss what happens in the really low levels.
- I don't want to see us setting guidelines and rules around trying to deal with the 2013 drought every year because of the cost. In using the monitoring data, we should only use what the average is rather than trying to deal with the 2013 drought on a regular basis.
  The purpose is not to try to deal with the 2013 drought on a regular basis. What we are looking at is the relationship between oxygen and flow. For example, if the flow in 2017 is 500L/s, then it is predicting that the oxygen levels will be good. If the flow is 200L/s, it is predicting that the oxygen levels are going to be low. We are not predicting for a year, you are predicting for a given flow. SO if you have a drier year there will be lower flows.
- Sandy explained that flow is a small part of the issue and temperature is a much bigger part.
  Flow is a small issue when it comes to temperature, flow is not a small issue when it comes to oxygen levels. That's a key point.
- Is flow a velocity or volume of water?
  Flow is litres per second, so how much water is passing a certain point per second, as a volume per second. These models look at both the velocity and the depth together in predicting oxygen levels. Once you have the depth and velocity you then look at for a given site what flow you need to achieve that.
- Further information is being provided verbally than what is presented on the slides and it was requested that in the future summary notes are put on the slides to enable the TANK representatives to report back to their communities.
  There is a full technical reports behind it with more details, particularly around uncertainty.
- Is the NPS bottom line of 50% or 40% not achievable? Thomas is recommending 40% but it was also explained that the NPS limit of 40% may not be achievable.
  Neither of these bottom lines are achievable in low-gradient streams. The 40% is not achievable because of the short timeframe of 5 minutes per year. A snail crawling over the sensor would cause non-compliance. The 50% bottom line, which is a 7 day minimum, is not achievable in many lowland streams. Thomas is recommending 40% oxygen saturation as a 99 percentile or a 7 day minimum.
- This is based on modelling information?
  No it is based on observed oxygen levels in lowland streams.
- When you have no data and oxygen levels are at zero, this indicates an urgent situation.
  We are not predicting what would happen if things got worse, we are looking at what is happening now.
- Why did the external peer reviewer not agree with Thomas's recommendation?
  The peer reviewers considered that streams not meeting the bottom lines were not meeting them because of poor management. Thomas is proposing that some of the streams are not meeting the NPS bottom lines because of physical limitations on these streams.
- How does the results showing that there are healthy fish in the stream despite dropping below the NPS-FM bottom line support Thomas's recommendations?

The oxygen levels in the Raupare Stream are below the national bottom line but there are healthy fish communities in this stream. Oxygen levels in the Raupare Stream have been observed to be above 40% oxygen saturation 99% of the time. Oxygen levels in the Awanui Stream have been observed to drop below 40% oxygen saturation and there has been an impact on fish health in the Awanui.

- The Awanui Stream has been modified for drainage purposes. When modifying streams for drainage purposes the streams are typically dug out deeper and wider. If we narrowed the Awanui Stream which would increase flow velocity, would we be able to increase the oxygen levels in the stream?
  Yes potentially. A more obvious example would be the old Ngaruroro channel (Clive River) which has a huge channel and the Ngaruroro River is not flowing down there at the moment.
- With less plants present (slides 75 – 76), is the oxygen level higher in the stream in the morning?
  Yes.
- It has been demonstrated that temperature in the Raupare Stream is lower. Could fish be going there because the stream is spring-fed not because the oxygen is sufficient?
  Fish need both. The oxygen supply needs to exceed the oxygen demand. So if the temperature is cooler, oxygen demand of fish is reduced and oxygen supply is higher because the spring flow increases the mixing.
- Can you improve oxygen supply in the stream by using artificial riffles?
  Generally no because the riffle will increase oxygen levels downstream but to create riffles you would need to build up an area. In a low gradient stream if you build up an area about 0.5m fall, you will back up 1km of still water upstream. You will create more still water than you will aerate.
- Would putting a propeller in the stream aerate the water?
  You could try it.
- With areas of shading and no shading to the north of the stream (slide 75), you have quite a difference in the fish species present and that's going to change the population and size of the fish. Is one population better than the other?
  In some streams we are at the point where even small fish don't live there.

7. Item # 5 – Karamu Catchment: Drainage and Flood Management

Gary Clode provided a short history on the Te Karamu Report. One of the goals is to manage the waterways for more values than drainage and flood control. HBRC has undertaken to manage all of our waterways for the range of possible values such as ecological, historical, landscape and cultural values, but flooding and drainage management has to take primacy.

Gary presented a summary of the history of major floods on river banks and the Heretaunga Plains. This is summarised in attachment 1.3.

<u>Matters raised by the TANK Group:</u>

- How was the conveyance in the waterway in the first example (slide 99) doubled? By flattening out the slopes?
  Conveyance was doubled by flattening the bank slopes and slightly widening the bottom of the stream.
- It was noted that in the photo (slide 103), showing a challenging waterway to shade something has to be done regardless because of bank slumping and ongoing erosion which will eventually result in losing some of the orchard.
  Agreed. If you don't plant it, you will lose part of the orchard. If you plant it out with shade trees the argument might be that you may lose a lot more land that could be used for orchard.
- In hindsight, if you were solving historical problems today, would you do it in the same way (i.e straight, high sided drains) or would you do more of what is shown in the examples (slides 99 – 102)?
  Definitely, do it differently because there are so many benefits. If you look at the whole range of values there are aesthetic benefits, biodiversity benefits, ecology benefits, and equal benefit in terms of the drainage. It is a far better, far more interesting and far more beneficial drainage arrangement than a straight linear drain. The objective is to replicate what would have occurred naturally.

- A comment was made that there is huge potential for two stage ditch design. This design is requires more land but it could be argued that you will lose the land anyway through things like bank slumping so it would be better to buy the land and get the benefits of a two staged ditch design reducing the loss of nitrogen, phosphorus and sediment to the system. This would be better than continuing with management as usual.
- How wide can the drains be before you need to plant both sides to get adequate shading?
  Difficult to say just off the top of my head. We normally use a standard digger for our mowing operations but we do have access to a long reach digger.
- Could we shade one side of the Awanui Stream on the north side and still have access to the other side?
  You probably could. Not a lot of work has been done yet in the area of full shading versus partial shading.
  In one of the cases where we carried out an Stream Ecological Valuation (SEV) then did some enhancement work we have recently carried out the SEV again. Overall the SEV score improved but it didn't improve on the shading. This was disappointing but when we looked at why we realised it was because we only planted shurbs at this stage and there are no big trees growing yet. Next time we carry out the SEV we are expecting a big change. On a wide stream if you have the ability to plant larger trees eventually you can probably shade both sides.
- For different flow rates is there an angle that you are aiming for? There are some streams that will take water during floods and less water at other times. If you slope one side of the bank and not the other do you need to increase or decrease the side of the slope that you are working on and then that affects your maintenance. So is there a guideline that you use for that?
  We have not established any guidelines but if you are trying to increase the conveyance and only change one side you can do that but remembering that all of these options, particularly where you are planting the banks, become expensive because often the maintenance costs certainly in the first few years has to be done by hand (which is 10 – 20 times the cost of using a mower 3 or 4 times per year).
- Buying up the land around it is not a feasible option when you have land use like vineyards but how are we then going to maintain these sloped drains when it is private property and you have to get in there and maintain it? It's fine to say you want shading but we have to maintain it.
  Maintenance is a factor that the TANK Group will need to consider. Landowners could do more themselves. There are some landowners that have supported this kind of work and really want to do it. That's one way of doing it. But don't mix up riparian planting for reducing nutrient input to the stream which could be 10 – 20m wide with riparian planting for shading where we are only talking about a single row of trees. Weeping willow are beautiful trees and will shade a huge area. If willows were interspersed with some low overhanging shrubs they will do a great job of shading even though it isn't 100%.
- Just don't have a subsurface drain anywhere near willows because the roots will block the drain.
  Any plant that you put in will need to be maintained. You can't just plant them and walk away.
- Does the flood control scheme cover all of the Karamu Stream catchment?
  Yes.
- Are the 164km of drains (slide 93) controlled by Council?
  Only on land that HBRC owns.

  Further discussion on the nature of drains/rivers is summarised above with item 3

Recommendations for Important Issues for the Karamu Stream catchment

HBRC staff formulated some recommendations and next steps for the TANK Group to consider. *Do you agree with these recommendations? (Amendments following discussion shown.)*

Recommended objectives:

1. ~~Main~~ Primary attributes for managing Karamu water quality are dissolved oxygen, temperature and flow.
2. The management objectives are
   - to reduce aquatic plants (a long term goal to ca. 30% cover)
   - to improve MCI (long term)
   - to improve fish health (short term).

Next steps

1. HBRC to develop options and priority for planting and stream redesign to be reported back
   - Public land by councils, Private land options, including Māori land
2. HBRC to report back on flow management
3. Further discussion and information on nutrient management and wetland management

The TANK Group also discussed the following matters:

About the **Recommendations**:

- Pekapeka and Poukawa wetlands have not been included. Is this being picked up by the Wetland Working Group? What kind of monitoring has been carried out there and how can we make deliberations on them without having the information about the behavioural benefits of these two wetlands?
  We have not had time do this today. This will be put together later. I don't know what the management of the Pekapeka and Poukawa needs to in order to protect their values and the difference that makes to the lower streams. It has been identified that keeping water up there is a key goal to work towards.
- HBRC monitoring has shown that 58% of the dissolved nitrogen in the Karamu Streams comes from the Poukawa system.
  This needs to be considered further. That is why the first recommendation has been made. The stressors in the Karamu Stream are not nitrogen, they are oxygen and temperature. We suggest a focus on oxygen and temperature for the Karamu then come back to looking at how we manage nitrogen load in the estuary. If we have to change the nitrogen load into the estuary we need to look for the source and what opportunities are available to reduce that load. This is a conversation for the estuary not for the Karamu Stream.
- Hasn't monitoring shown that nutrients prevail in almost all of the Karamu system?
  It has also been identified that reducing nitrogen and phosphorus levels in the Karamu would not necessarily mean a reduction in macrophyte growth. We manage the nutrients for what is happening in the estuary. Additionally, regarding nitrogen, we have to make sure that nitrate and ammonia levels do not exceed toxicity thresholds. But the key stressor in the Karamu for invertebrates is dissolved oxygen and temperature.
- To control the Karamu, we need to look at the Te Hauke area and Poukawa for the water that is there, wild fowl, etc. We can't look after the Karamu if we do not look after the headwaters.
  We can't dismiss nutrients from management. The first recommendation is made for life-supporting capacity. We can't control macrophytes with confidence by managing nutrient production so we are recommending that we look at temperature, oxygen and flow. We can add a statement for what to do about nutrients, what targets, when we do something about nutrients and how that might be done. This reflects that importance of the impact of nitrogen

on the estuary. We may also need to look at the nitrate component of DIN or ammonia. Management of DIN would be to control algae (not aquatic plants) and we also need to look at toxicity with the nitrate and ammonia guidelines, particularly in relation to the estuary. Managing nitrogen would address matters beyond the life-supporting capacity. We still need to discuss this.

- Have we got an example of seeing improved planting and what difference it makes? It could make a substantial difference if we go ahead and plant. *Post meeting update: Sandy will provide reference post 23-Feb 2017.*
- Why is the recommendation to reduce aquatic plants to 30% cover?
  That figure comes out of a study looking into how much oxygen aquatic plants take out of the water at night time versus the amount of habitat the aquatic plants provide. Thirty percent cover provides enough habitat for healthy communities and results in not too much oxygen being taken out of the water column. The recommendation is to reduce cover to 30%, not to reduce existing cover by 30%.
- What does the recommendation to improve fish values in the short term mean? What management options are being considered?
  The presentation this morning was about different oxygen levels and alternatives to limits in the NPS. Those alternatives could provide for fish values but they might not provide for improving the MCI scores.
- We are looking at avoiding fish kills by avoiding reduced dissolved oxygen levels in the water. It's about providing safer habitat for fish by providing the right oxygen and temperature levels.
  There were two levels presented. The first level is to avoid fish kills and provide for diverse fish and healthy fish. The second level is better MCI scores and more diversity.
- Would a management option be setting and implementation of low flows?
  Two management options have been suggested, management of flow and riparian planting.
- The riparian planting would take time but the low flows could be implemented when the plan change is complete.
- Would monitoring of fish values be through assessing fish numbers?
  The attributes that would be measured would be oxygen and temperature in the stream. Limits need to be set associated with fish values.

About the **Next Steps**

The TANK Group raised the following matters about the **Next Steps**:

- Acknowledgement of a different class of land that might arise through Treaty claims such as iwi owned land or land with multiple ownership. It will be important to look for feedback not just on how HBRC manages its land but also what are the opportunities for provisions in the plan around private land.
- We need to develop understanding about priority areas and areas where we might aim for different targets/limits/attribute levels and bring in the drainage management aspect.
- What does reporting back on flow management mean?
  There will be further reporting in relation to point # 2 as management scenarios are tested with the models including options for managing flows in relation to managing ecosystem health in the Karamu and how that is informed by the modelling work.

- Is there anything special we need to be thinking about for the discharges of stormwater into the Karamu Stream? What are the impacts?
  This is part of the wider s/w management focus by the SWG
- We need to do something about sediment in the Karamu Stream catchment. Presentations today show that sediment is a big issue, particularly around oxygen. *Post meeting update: We don't know how big the effect of sediment on DO in the Karamu is at this stage. Generally when there is high organic content in the sediment, then the process of breakdown takes up DO out of*

the water column. So that organic fraction in the sediment layer can originate from land (external input), but can also be macrophytes breaking down from within the stream, then it doesn't have anything to do with erosion.

- Concern raised around including options for alternative drainage methods. Does point # 1 include looking at other means for conveying flood waters?
  It is more about looking at what management solutions exist that allow other objectives as well as the flooding/drainage objectives to be met.
- As part of the stream redesign, add reporting back on options for different levels of service.
  This is relevant to point # 1.
- Add contribution of the relationship between groundwater and surface water on the Karamu.

Key conclusions from the TANK member discussion:

Recommendation # 1, the TANK group agreed:

- Change "Main" to "Primary"

Recommendation # 2, the TANK Group requested:

- Further information to be provided about how to classify drains modified water courses and streams/rivers
- Ensure management of water quality in watercourses and drains accounts for impacts downstream
- Ensure there is scope for different management objectives for different types of streams including for maintenance of adequate drainage functions

In regards to improving MCI and fish health, the group needs a definition of what a "drain" is, i.e. what waterways are there for fish life and what waterways are primarily there for flood protection

Next Steps # 1, the TANK Group requested:

- Consider also land with multiple owners and Maori owned land
- Include options for alternative ways of conveying flood waters
- Include options for different/alternative levels of service as part of stream redesign.

8. Item # 6 – Heretaunga Modelling to Support TANK Decision Making

The purpose of the modelling presentations were to:

- introduce the models
- describe the capability of the models
- discuss limitations of the models
- demonstrate some applications of the models
- stimulate discussion of scenarios for modelling to inform decision making.

Overview of the modelling

Jeff provided an overview (slides 109 – 110). The "model" is not just one model, it is made up of a number of models to create an integrated groundwater-surface water model.

- HBRC is responsible for the MODFLOW model supported by GNS using HBRC data
- SOURCE SW modelling is undertaken by Williamson Water Advisory
- The groundwater nutrient modelling is being carried out in the MT3DMS model. Due to complexity that model is not yet complete.
- Irrigation demand and recharge modelling was done by Aqualinc.
- NIWA provided a lot of data.

A summary of the presentations by the modellers is provided in attachment 1.4 to 1.6

<u>Matters raised by TANK Group members included:</u>

- Would the springs input…52:00
- Why was a liner model used for long-term trends?
- Do we know the water residence time? Does the model have the capability to measure the age of drinking water sources? The GNS report produced for Hastings District Council showed that the age of water reaching the bore at Lyndhurst, Frimley and Portsmouth Road supplies is showing a high proportion of water less than 1 year of age. As a consequence, additional treatment is required for Hastings City.
  This is done in a flow model within the MT3D groundwater model that is being used to model the contaminants fate transport including the age of water. Age of water will be included in the assessment. Hopefully this will be calibrated by the end of this year.
- Does the model have the capability to investigate where it is best to abstract water for different land uses in different areas? Different crops need water at different times. Is there a way of using the model as a management tool?
  The model cannot really do this. We estimate the abstraction using a different model, the water demand model. Then we feed that into the MODFLOW GW flow model. We could try different data sets and assess how that impacts on spring flows and water levels.
- Can you differentiate the flow data for the different abstractions for different crops? It should be in the water demand model relating back to the effect on minimum flows.
  We have that data so we could take the graph shown initially and split it out into different components and different uses.
  That would be done in the Irrigation Demand and Recharge model. We can remodel that and put it into the MODFLOW model and/or the SOURCE model.
- Does the model have the capability to tell us whether there will be saltwater intrusion if the volume abstracted is too high?
  This model doesn't model saltwater intrusion explicitly, but it does give us a good indication of what might happen. For example, we have estimated a decline of 2m in groundwater level with the current abstraction rate ("Drawdown produced by current (actual) abstractions", slide 124). This does not change the conditions in the aquifer in that the artesian head in the aquifer remains which protects from saltwater intrusion. For modelling the drawdown caused by pumping the full allocation scenario ("Drawdown if maximum allocation was taken", slide 124), the head drops down another 2 – 3m. This would still keep artesian head in the aquifer but we would be getting close to

the conditions that would become dangerous. The drawdown modelled for the scenario if maximum allocation was taken is an extreme scenario of pumping and probably unrealistic. Under this scenario you would see a very significant stream flow decline in all of the streams that probably would not be acceptable. There is also potential for pumping causing localised saltwater intrusion.

- Stream depletion. It is complex to change the model parameters. The model is going to be important to assessing the economic impacts of any rules the TANK Group proposes. We will need you to run a lot of scenarios.
  Defining stream depletion zones is quite complex. It requires use of another package/model that we have not used before. But we have done a lot of work in this model that we have not done before. It is not something that could be done in a matter of days so it would be really good to get the scenarios that the TANK Group wants modelled narrowed down as soon as possible.
- If the model shows that if abstracting the maximum allocation (slide 124) is dangerously close, would you recommend allocating no more water, capping the allocation?
  That is something for the TANK Group to decide.
- Even if this scenario is unlikely, we need to be taking a precautionary approach to managing water while we wait for the model. If we are dangerously close with what is already allocated and there is potential that we could reach that, if we keep allocating more water we could go past dangerous so it wouldn't be wise to allocate any further water.
  We can model increasing the allocation and looking at what that would do to explore this further for you. For example, model 1.5 times actual use, 1.5 times allocation. We can bring further scenarios back for you in March.
- If there are springs discharging into the Heretaunga Plains flood control and drainage scheme and the purpose is for drainage then there is a conflict with the Heretaunga Plains flood control and drainage scheme because the aquifer is being dewatered. If springs are discharging into the drain in order to drain the land, the quantity of loss through the flood control scheme is dewatering the aquifer.
  That is an issue associated with abstraction not flood drainage. The more water that is abstracted the lower the spring flows are and that can be modelled as well. The modelling scenario in slide 124 shows the impact on groundwater levels not the impact on flows. The model does also show that there is an impact on springs and we can carry out more modelling scenarios.

Application of the water models to understand aquifer recharge scheme effects

Jeff presented on an application of the model relating to estimating the MALF and minimum flows in the Ngaruroro River at Fernhill.

<u>Matters raised by TANK Group members included:</u>

- How did the testing on the artificial recharge work and at what level? It was reduced from 3000L/s to about 600L/s. Why was it reduced?
  We modelled from 1998 when we have the flow records, which was after the minimum flow was increased and the take was reduced. Before that we had to guess.
  Not sure why the take was reduced and the minimum flow was increased during the consent renewals. But during trial when they took 800cumecs there was no need to take that much because they could not physically get all that water into the aquifer anyway.
- What is the level of confidence that the recharge scheme worked?
  Yes the evidence we have shows that it worked and it could be improved. The artificial recharge was just one place in the HBRC area. There are other locations and depths and if an injection well was installed too recharge could be more effective. There are different ways of managing it.

SOURCE Surface Water modelling

John Williamson, of Williamson Water Advisory, presented on the SOURCE SW flow and nutrients model collaborative effort between the company and HBRC staff. The SOURCE Model predicts flow in the surface water streams and catchments along with the fate and transport of nutrients within them. His presentation is further summarised in attachment 1.6

Matters raised by TANK Group members included:

- Did the flow calibration (slide 9) use the naturalised flow or actual flow with abstractions?
  Actual flow.
- Do you have the abstractions in the model?
  Yes. The same data as that used in the Modflow GW model.
- What is the commencement date?
  Model starts in 1972 but there is a "warm up period" so we don't analyse all of it. The first 5 years of data is set aside because it takes a while to get it set up, running and reporting correctly.
- The timing of the ban is important as well as the frequency.
- For the Tukituki catchment HBRC used 10 consecutive days on ban and it would be helpful to have that scenario tested in the model and when it would happen.
  Tukituki River assessments used a wide range of assessments. Part of the process through the TANK Economics Working Group is discussion about the effects of different numbers of consecutive ban days. Narrowing down the types of statistics that are generated is necessary so that people can look at what is important. HBRC also needs feedback from the people doing the economics work because there may be some key statistics from an economics point of view (and that might be a standardised type of statistic that is used across the country). HBRC is open to the type of statistics generated and providing that it is appropriate for all of the parties.
- The timing of bans is critical as this relates back to the timing of water needs for different crops. We need to know more specifics around the timing and duration of bans.
- Can you model staged reductions in the volume of water that can be taken under consents? If yes, could you look at whether staged reductions would slow down flow recession/reduce how soon a minimum flow will be reached in a river to any degree of significance?
  Yes that is what Source model is designed to do.
- Water storage has been discussed from time to time for the Ngaruroro River catchment. Could the model assess the impact of that on flows?
  Yes including looking at water releases.
  Managed aquifer recharge could also be an option for water storage.
- Does aquifer recharge operate only during the winter or summer as well?
  It was operating all year round. But as the minimum flows were raised, the recharge during summer would have dropped because there was less water available.
- Did you do naturalised flow at Fernhill and then add back abstractions on top? Have you tested that to see if that works? In practice when we shut off the water we haven't seen the response at the Fernhill bridge. Are there other losses between there and the Fernhill bridge? When we had a series of drops in flow in the 2013 drought we had a good idea of who was irrigating what because we were rationing water. HBRC will have the water meter data. If we all stop irrigating we only got about a third of the response we were expecting to see.
  We can test that with the GW model if it is groundwater takes that cease taking and look at the response time. We can look at from the time takes are shut off how long it takes for a response to be seen in the river and how long it takes for it to be of benefit.
- What about surface water takes?
  Yes we can look at that too.
- We have talked about leaving water for longer in the river and introducing staged reductions sooner.
- Allocation and water use are completely different. The allocation sets a limit that you might never reach so we should really work on water use. With telemetry we have the capability to measure daily the amount of water taken.

Additional Questions on Models

Due to the short time available, not all of the technical questions (some outlined above) could be answered on the day but the groundwater/hydrology team is happy to have a technical workshop with the TANK Group at another date to discuss the in-depth details of the models.

9. Item # 7 – Minimum Flows for the Heretaunga Plains

Thomas provided a recap on previous agreements the TANK Group had made in regards to setting minimum flows and the RHYHABSIM model. Surveys have been undertaken in the Ngaruroro River near the expressway and the Tutaekuri River at Ngaroto. Thomas showed an example of the model output showing the rate at which habitat declines with flow. The model doesn't provide a minimum flow itself. The model tells us how much suitable depths and velocities change with flow. This can be used when looking at how much habitat we want to maintain in the stream.

A method we've often used is to look at how much habitat is available at a typical flow like MALF, look at maintaining a certain percentage of that habitat, and look at how much flow different fish species need to maintain that habitat. This allows us to look at different habitat retention levels and provides a tool to help stakeholders make decisions. Thomas showed examples of this calculated for the Ngaruroro River and Tutaekuri River previously. The MALF has a big influence on specific values. These numbers will change with a revised MALF (slides 156 – 163).

<u>Matters raised by TANK Group members included:</u>

- In which direction with the revised numbers change?
  If you reduce the MALF, this will reduce the recommended minimum flow for the species that require high flows, i.e. the maximum habitat is about the MALF and the MALF is used as the starting point. Normally you have some high flow demanding species used as a reference flow.
- At what portion of habitat are species sustainable? At what point are you going to start losing stock? What about in terms of general degradation (rather than a population collapse) and sustaining current levels of species?
  No I can't say at which point population would collapse. When you are talking about 90% protection levels, you are looking at trying to avoid situations where flow is constraining that population. If you managed to actually keep flows at 90% habitat protection level you would avoid big reductions.
- We have some important decisions to make and it would be helpful to have professional fisheries advice to guide us. Are there staff within HBRC or funds within the budget to engage people to provide advice? None of us have the level of experience to be confident in making those kinds of decisions.
  This approach has been recommended by John Hayes and Ian Joude. John Hayes and Ian Joude essentially copied what Thomas developed for Bay of Plenty. Thomas developed this approach for Bay of Plenty Regional Council because it is a difficult decision and challenging in terms of how you make this decision for every resource consent across the region because it is subjective. Consistency was the aim so we proposed to use 80% protection level and discussed it with DOC and Fish and Game to become a standard. It was not intended for this situation with one or two consents, hundreds – thousands of consents were affected. We do not have the biological information to say for example how many trout you would lose. No one has that information. John Hayes gave expert evidence on the Tukutuki PC6 on this issue. There are experts that we can call in to talk about implications of this but you will not be able to get numbers as specific as numbers of fish lost, it is conceptual.
- How relevant is that information to the scenarios the group puts forward to today? Do we need the information to make decisions now or can we get it further down the track?
  Today we need to narrow down the options because we can't model all scenarios so we can get back to you with some consequences. For example, in terms of what are the implications for security of supply we can only look at so many scenarios.

10. Item # 8 - Modelling Levers and Scenario Development

Rob presented on the kinds of groundwater modelling parameters/levers and surface water modelling parameters/levers that can be changed in the groundwater-surface water modelling to look at different scenarios (slides 179-182). Two initial scenarios modelled were naturalised scenario and current/abstraction scenario. Further scenarios can be modelled for the TANK Group to assist in making decisions on management of groundwater and surface water takes.

Rob briefly explained the following scenarios using surface water modelling levers for different restriction regimes:

- Minimum flows (slide 183)
  For example, if minimum flow is based on habitat modelling, the group could look at targeting a particular fish species or groups of species (fast, medium and low flow species) or percentage level of habitat protection.
- Staged reductions (slide 184)
  Develop stages for the amount of allocation that can be abstracted depending on changes to flows in the river. Rather than using arbitrary numbers, potentially a good approach for this could be to use the levels of habitat protection to establish certain stages of reduction.
- Flow sharing (slide 185) – where flow is shared between water users and the river

Before a breakout session l, Rob presented on three examples on potential scenarios to model focussing on the Ngaruroro and Tutaekuri Rivers (slides 187 – 188). You can look at different modelling scenarios for different catchments or use the same scenarios for both catchments. For the allocation regime it could be useful to model for an increased allocation but at this stage it is recommended that the group look at the full results of the current allocation. Once the group has those results there may not be any desire to look at changing the existing allocation. The focus of the breakout session was to get some feedback on modelling scenarios looking at things like:

- type of restriction regime that the group wants modelled and whether that is a combination of minimum flows on their own or a combination of minimum flows with staged reductions or combination of minimum flows and flow sharing or another combination that hasn't been mentioned yet
- type of target species the group wants modelled, i.e. fast water fish or different types of species or different levels of habitat protection.

When HBRC has a range of scenarios from the TANK Group HBRC can prioritise and look at when the scenarios can be modelled.

Brian Bell offered to email out to the TANK Group a diagram of how this would be modelled in terms of economics. Eventually it will end up in an economic model which will shows the costs and benefits.

<u>Matters raised by TANK Group members included:</u>

- What is the current total allocation of surface water from the Ngaruroro River in litres per second?
  Somewhere between 1 – 2 cumecs
- Could we look at combining flows with other interventions? For example if someone is prepared to plant trees they get a concession with some extra flow because there is more oxygen in the water. That could potentially create an incentive for people to do that planting.
  Difficult to model because that would be looking at individual takes. We are trying to look at an overall allocation limit across the plains and surface water. Instead we could look at writing incentives into rules for example to a consent holder that is applying to take some of the allocated water so it could become a condition/requirement of the consent.
  We are open to suggestions and ideas. We would need to look at whether or not we could use the models we have to simulate that kind of setting. If we cannot do that directly we could look at an alternative indirect approach, for example, different land use scenarios combined which might change one of the characteristics.
- Rather than looking at annual allocation volumes, it was suggested we look at the long-term average or a system of carry overs or overs and unders. We are worried about the long-term effect on the aquifer. If there is the ability for non-stream depleting groundwater takes to use overs and unders that would be effective use of the resource. It could be a useful tool to get over extreme events like the 2013 drought.
- Can we model at three scenarios presented in slides 187 and 188?
  Yes. But it would be helpful to have some scenarios that are more specific that the TANK Group would like HBRC to prioritise.
- How many scenarios do you want from the TANK Group to model?

Anything at this stage. HBRC has an idea of what could be modelled but HBRC does not want to model scenarios that people think aren't practical or are not likely to go through to a plan change. HBRC is looking for direction on what the community and stakeholders want modelled so that HBRC can prioritise the work they do. There is a lot of work involved. These scenarios also feed into the economics work so we need to streamline them to a point.

- How many can HBRC handle?
  It depends on the level of complexity of the scenarios. For example, modelling a combination of minimum flows, staged reductions and flow sharing all together it could take a while to set up. But if it was just to change the minimum flows or allocation that would be fairly straight forward.
- Using MALF to quantify minimum flows was questioned. The existing model is a Q95 which uses an existing MALF to realise what is available over the irrigation season. Taking the higher flows and using a percentage of those as an allocation framework within a 6 month irrigation season creates a false impression that MALF applies to the whole year but the critical time we are trying to address is the 6 month irrigation season when the higher flows are not always available.
  MALF is not the mean over the whole year. MALF is the average of the lowest 7 days of each year. It is the lowest level the river reaches each year. It is a summer low flow not a winter low flow. It is not influenced by winter flows.
- Is there assurance that this does not apply to the Karamu and Clive and they will have a separate assessments?
  Yes the Karamu catchment will be modelled as well but there may be a different restriction regime, for example utilizing the oxygen flow modelling carried out by Thomas. Thomas talked about potentially setting minimum flows in the Karamu catchment based on oxygen limits.
- It includes nutrients and metals, etc. The Karamu Stream and Clive River go through an industrial area.
  Today we are focussing on water quantity. Nutrients will be dealt with through the water quality component of the surface water and groundwater models.
- More information was requested on the conditions necessary for taonga and mahinga kai species such as patiki and koura.
  The problem with Patiki is that we do not have habitat suitability curves. We don't have numbers on what water depth and velocity, and what substrate Patiki prefer to feed into the model. We cannot generate a numerical prediction for it. We have carried out literature reviews and came to the same hurdle. Maybe within the 10 year life of this plan we can undertake the work and there is a commitment to further research We can consider it further. We can look at the options we come up with and use local knowledge to see if it seems reasonable. (Note that torrent fish are a high flow demanding fish and a taonga species. If flows protect this fish then they will protect other fish)
- More information was requested on the artificial recharge scheme and sites that can be used to expand the scheme
  HBRC does not have any alternative sites identified yet. HBRC has just finished the assessment of the effects of the previous recharge scheme.
  It could come under the consideration water augmentation group. If it is a shortfall in security of supply then it is something that can be explored further.
  We can use the groundwater model to explore different options as the effectiveness of different recharge scenarios.

Summary of possible modelling scenarios suggested by TANK Group members:

- Model scenario based on the Ngaruroro River Water Conservation Order application
- Conceptually to see use of the aquifer of unconnected groundwater takes as a bank and look at the long-term average or a system of carry overs
- Age of water
- The examples presented by Rob
  HBRC to refine these further and get back to the TANK group with something more polished.
- Explore effectiveness of recharge scenarios
- Different high flow cut offs to provide for taking water for offstream storage to be subsequently used in augmentation to offset effects of water takes
- Providing emergency water for tree crops that may die (i.e. look at how low will the flow would drop)
- Different minimum flow triggers with rationing introduced in steps

Action items

25.4 HBRC to refine the scenarios for modelling presented during TANK#25 and get back to the TANK Group with something more polished.

11. Item # 9 – Other Matters

- There were no working group updates.
- HBRC can schedule another meeting to continue the mornings' session.
- It was raised that Oli has talked about how land use affects the coastal environment and, although it will be outside the scope of the RRMP, we need to talk about setting limits. We need to make sure management is integrated.
  We will be having a separate meeting for the Waitangi Estuary and we will be discussing the Ahuriri Estuary at the February TANK meeting [post meeting note – Ahuriri now scheduled for March]

12. Karakia and close.

The Group said a karakia together and the meeting ended at 4:30pm.

Summary of Action Points

ID	Action item
25.2	Circulate Item 5 on sediment before the next TANK meeting on 9th February 2017.
25.3	Further information requested about what a drain, ditch and river means and what implications this has for deciding on objectives and management responses
25.4	HBRC to refine the scenarios for modelling presented during TANK#25 and get back to the TANK Group with something more polished.

Attachment 1

1.1 Summary of presentation on the Karamu catchment by Sandy Haidekker

Contact recreation/human health NOF

E. coli levels meet the guidelines for secondary contact recreation but fails the bottom line in all of the waterways (presented on) except for Mangarau Stream site for primary contact recreation.

There is always *E. coli* present. They are not always pathogenic, *E. coli* is an indicator that faecal contamination is present and a risk indicator. Faecal source tracking has been undertaken to determine the source of the bacteria. For Clive at the boat ramp, only 10% was from ruminants and the rest from plant material and birds. Faecal contamination from plant material might be bacteria from ruminants that has settled and replicated on the plants. We do not know how pathogenic these bacteria are and this is a question being investigated by working groups at a national level. Bacterial material from aquatic plants is not of the same risk level as it is from ruminants or human pathogens. We do not have information to address this yet, it may come in through the NOF.

Nitrate and Ammonia toxicity

NOF bands (slide 20): Usually in quite good condition over the long term but there are exceedances of the maximum toxicity for ammonia in the Karewarewa and Awanui Streams and for nitrate in the Karewarewa Stream.

SOE data DIN and TN (slide 24): High in some of the streams most of the time. DIN always very high in the Mangarau Stream at Te Aute Road and TN always high in Karewarewa, Awanui and Poukawa Streams.

SOE data DRP and TP (slide 24): Exceeds the guidelines at all of the sites almost all of the time.

Trophic state

Algae are well correlated with nutrients because their only means to take up nutrients is through dissolved nutrients out of the water. However, algae are not dominating in the Karamu Stream catchment and cannot be used an attribute for trophic state so for the Karamu catchment sites (with the exception of the two Mangarau Stream sites).

Water Clarity

SOE data: mixed results between the monitored sites (slide 24).

Ecosystem Health

The general aquatic plants in the Karamu catchment are macrophytes. They are not so well correlated with concentration of dissolved nutrients in water because they have roots and take nutrients out of the sediment. Therefore macrophytes are not a good indicator for trophic state. But macrophytes can indicate ecosystem health outside of the NOF, using aquatic plant abundance as a measure.

Algae and aquatic plants, and MCI attributes were reported using SOE data (slide 24).

Algae exceed the threshold at the Mangarau Stream sites where there is gravel. All of the other sites are dominated by aquatic plants. Most of the SOE data exceeds the thresholds with more than half of the channel dominated by macrophytes.

MCI indicates that the life supporting capacity is not there in the Karamu Stream catchment. This led to a targeted study which Sandy previously presented. Key points are summarised in slide 25. We should be able to manage this catchment with better ecosystem health. The problem in the Karamu catchment is that there are so many different stressors. This catchment is different to the Ngaruroro and Tutaekuri River catchments. The Ngaruroro and Tutaekuri River catchments are larger and have gravel river beds and we do have a long tradition of managing that. But in the lowland streams there is a complex interaction between the different stressors which are correlated with each other (i.e. if you change one stressor it can affect other stressors) (slides 26 – 27). Sandy presented further on some of the stressors that can impact on life supporting capacity. The targeted study looked at different stressors at the same time and how they correlate with loss of sensitive taxa. Three main problems were identified. Key factors correlated with no sensitive taxa being present were high temperatures and low oxygen. Habitat was also correlated with shifts in the community. Te Waikaha Stream and Awanui Stream were explained as examples of good and poor ecosystem health, respectively (slide 28). For the monitoring site data with samples taken at the same time, dissolved oxygen, temperature and MCI were illustrated compared to the draft NOF guidelines (slides 29 – 32).

- Dissolved oxygen (DO) for Te Waikaha Stream sits in the A band, but most of the streams had DO levels below the bottom line for oxygen (4mg/L), and the rest are sitting around 5mg/L. This is very low. Many of the streams had a DO below 2mg/L in the worst times, in the hottest summer days. The description for the D band includes significant persistent stress and local extinction of keystone species (no sensitive taxa anymore) and loss of ecological integrity.
- Temperature was commonly above 21 degrees Celsius and often in the range of 23 – 25 degrees, sometimes higher than 25 degrees. The problem with temperature is that it fluctuates diurnally and it is not really important for the animals themselves to have absolute maximum temperature because that might just prevail for half an hour. So either taking the 95th percentile or calculating the midway point between the daily average and maximum temperatures has more meaning in terms of impact because it prevails for several hours and that is something that is more stressful for animals. There is an ongoing discussion for the NOF guidelines as to how to report on temperature.
- Both the hard-bottom stream MCI and soft-bottom stream MCI were reported. The results show that it does not make much difference to the MCI classes for the stream sites monitored but the soft-bottom MCI does report lower MCI values in the Karamu Stream catchment.
- In the streams where the temperature is below 20 degrees and the DO is above 5mg/L there is good stream health and the MCI is above 100 showing that we can have good health in the lowland streams as well. In streams where the temperature is above 21 degrees and DO is very low, the MCI drops.

The draft guideline for dissolved oxygen is set for below point source because at those points we know the issue comes from a point source pollution. If you are looking dissolved oxygen outside these areas, as a result of the complex interactions between oxygen and other variables it is not quite as easy to manage dissolved oxygen. For sites outside of these areas, you would need to look at the sites themselves and the reaches where there are problems to find out the problem causing low oxygen levels, then have a management strategy for those problems.

Sandy provided an explanation of the system, risks and what takes dissolved oxygen out of the water column (slides 33 – 35) to help provide an understanding of management of various aspects, particularly in the Karamu catchment where the oxygen depletion is not caused by point source discharges:

- Oxygen comes from the air and this depends on flow, more oxygen can enter the water as turbulence increases
- DO can be taken out of the water by the process of decomposition of organic material in the sediment
- Plants produce oxygen only during the daytime and they take DO out of the water column when they respire during the night resulting in DO being lowest during the early morning hours
- Animals living in the rivers take out DO and they are dependent on how much DO is in the water column. This is coupled with temperature.
- Cooler water has a higher oxygen holding capacity. Gases disappear from the water when water temperature increases. Temperature also directly affects animals. Animals do not regulate their body temperature like humans do, they rely on the temperature of the surrounding water. The higher the temperature, the higher animals' metabolism and the more oxygen they need. This is a problem because when water temperature is higher, there is less DO in the water for animals to use.

A summary of the outcomes of the study and stressors in the Karamu catchment was illustrated and summarised (slide 36).

Waitangi Estuary

The state of the estuary is influenced by inputs particularly sediment and nutrients.

Seeking advice on practical solutions

Sandy noted the interdependencies of the complex aquatic ecosystem in the Karamu. She reported that further advice was sought on what can be done in order to improve the life-supporting capacity in the Karamu Stream catchment.

Aquatic plants are a centre pivot point because they affect oxygen directly but also attract sediment, and they also need sediment to grow in. Aquatic plants also provide habitat so we do not want to eradicate them completely. They can clog up the channel and affect the flow. Aquatic plants are not well correlated with dissolved nutrients so we do not know how much we need to reduce nutrients to manage algal plant growth.

The advisory group has produced a report (still in draft stage) and the findings were summarised by Sandy. Information was presented on the advantages, disadvantages and challenges of using different methods to influence the main stressors temperature, low DO and habitat aquatic plant growth and what stressors are affected if we manage aquatic plants using:

- Riparian planting (illustrated in slides 38 – 39)
- Herbicides (illustrated in slides 40 – 41)
- Mechanical macrophyte removal, grass carp (illustrated in slides 42 – 43)
- Nutrient reduction (illustrated in slides 44 – 45)
- Flow augmentation (illustrated in slides 46 – 47).

The downsides and benefits were summarised in slides 48 and 49.

1.2. Summary of presentation on the Karamu catchment by Thomas Wilding

Investigations

Thomas outlined the aim of the investigation carried out at sites in the Heretaunga Plains over the past few years with the purpose to inform the TANK Group recommendations and key factors which affect oxygen levels in the stream. The investigation did not look at the consequences of pollution discharges, it focussed on the flow relationship.

Oxygen is not a problem everywhere, it is a problem in low gradient streams (see slide 56) but less of a problem in streams that receive a lot of spring flow. A map was presented that illustrates how much flow you need to achieve 40% oxygen, relative to the Mean Annual Low Flow (MALF). For example, 300% means 3 times the MALF is needed to achieve 40% oxygen. If you need 3 times the MALF, that means that the flow drops below the MALF normally.

The Awanui Stream is particularly bad, oxygen levels can drop to zero and stay at that level for long periods of time. Examples of the changes to DO levels in the Awanui Stream and Raupare Stream in relation to 40% DO was illustrated in graphs. Raupare Stream is spring fed and has remained above 40% oxygen saturation most of the time over the past few years but the Awanui Stream has not (slides 57 – 58). This is discussed in a report produced by Thomas which has been distributed.

Thomas presented on a more intensive study carried out at three minimum flow sites on the Irongate, Awanui and Raupare Streams.

It was demonstrated that DO decreases with flow in the Raupare Stream but there is variability (slide 60). It is not the same DO for a given flow, that varies depending on factors such as the amount of plant growth. We have model predictions but there is variability around those predictions, you do not get one oxygen concentration and that’s it, you get a range. There are a number of ways of dealing with that outlined in the report, but the main way Thomas proposed is using a summer scenario. These severe oxygen conditions you will get for a given flow, particularly in a summer scenario versus an autumn scenario of less weed. An example of how the flows required for meeting certain oxygen saturation in the autumn and summer periods is different was presented for the Raupare Stream and for summer periods in the Awanui and Irongate Streams (which is in the report) (slide 62).

Options for Managing Oxygen

There aren't currently oxygen limits in the NOF and it is up to the TANK Group to recommend limits.

There are national bottom lines in the Freshwater NPS but they are for below point discharges, not a legal requirement here. But they are a logical starting point. The challenge is around achieving these limits.

Thomas presented on two options for setting oxygen limits.

Option 1 being those limits in the Freshwater NPS 2014, PC6 and the RRMP. There is bottom line of 50% oxygen in the NPS-FM. Oxygen saturation in the Raupare Stream and Awanui Stream over time in comparison to the NPS limits was presented (slides 65 – 66). The bottom line is being met in the Raupare Stream most of the time but not at the moment. In the Awanui Stream, even the median flow is producing oxygen levels below the NPS bottom line.

Therefore, Thomas recommended oxygen saturation lower than the NPS-FM bottom line. The peer reviewer did not agree with these recommendations. It is up to the TANK Group to decide.

Option 2 is Thomas's recommendation of 40% oxygen saturation for native fish in these low gradient streams or at least ("ambulance at the bottom of the cliff" scenario) a water velocity of 0.04m/s to stop the streams undergoing complete collapse of aquatic plants and resulting fish kills (slides 67 – 69). The reasons for recommending limits below the NPS-FM:

1. NPS not achievable (slide 70). The Awanui Stream was used as an example. The flows required to exceed the 50% standard in the Awanui are more than 3 times the MALF - far beyond what could be achieved by flow management. The 40% NPS standard was discounted because it applies for such a short period of time (5 minutes per year).
2. There are healthy fish in the stream despite dropping below the NPS-FM bottom line (slide 71). Results from the Raupare Stream and the Awanui Stream demonstrate that we are observing tipping points in these streams at oxygen levels less than the NPS limits. Both streams are below the NPS bottom line. One supports healthy fish and one does not.
3. NPS is too conservative in comparison to the scientific literature (slide 72). They are looking at the impact of low oxygen after continuous exposure for 48 hours. But in the streams we are looking at the oxygen levels do not flatline for 48 hours, at least not until flows are well below all limits under consideration. We are looking at impacts in streams where the oxygen levels fluctuate diurnally. The Raupare Stream was used as an example of a stream dropping below 50% oxygen each morning, but rising by day. When flow velocity is at 0.04m/s in the Awanui, oxygen levels are still fluctuating diurnally because the aquatic plants are increasing the oxygen levels during the day. Aquatic plants are key to keeping fish alive in the Awanui and therefore the velocity of around 0.04m/s is what is needed in the Awanui to keep the plants alive, growing and not smothered by algae.

Thomas then presented on other ways to manage oxygen.

- Shade. The more shade over the stream, the less weed grows (shown in slide 75), and the higher the oxygen supply (by about 10 – 15%). More oxygen either by reducing the amount of respiring plants or by reducing the amount of channel clogging. Channel clogging reduces water velocity and therefore the reaeration of oxygen.
- Temperature (slide 77).
  For fish to survive in a stream, the oxygen supply must exceed their oxygen demand (slide 78).
    - Oxygen supply is primarily driven by flow. We can manage stream flow and how much water we use and that affects the amount of mixing and reaeration of water and supply

of oxygen to fish. Aquatic plants play a small role in terms of clogging the channel and reducing the reaeration for a given flow.
- Oxygen demand is driven by temperature. If you increase water temperature by 10 degrees Celsius, you typically double the amount of oxygen that fish require to meet their needs.
- For these small streams, riparian shading is the most effective way of reducing water temperature and therefore with riparian shading you are managing oxygen demand. Through flow you are increasing oxygen supply from water to the fish. Oxygen supply must exceed oxygen demand to keep the fish alive.

This was summarised in slide 79. A slide of oxygen options was prepared (60% oxygen for MCI, 40% oxygen for health of native fish, velocity of 0.04 m/s for aquatic plant health to avoid collapse), with the intention of use in the break out session to discuss oxygen limits. In discussion, it was decided to change to a different break out session after Gary's presentation.

1.3. Summary of the HPFCS by Gary Clode

Prior to 1867 at Roys Hill the Ngaruroro River flowed southeast through what is now Flaxmere (which is now called the Irongate Stream), turned north and joined up at Clive. It was a gravel bottom stream at the time and gravel went all the way up to the coast.

During a flood in 1867, the Ngaruroro River chose a different course and flowed down through Pakowhai at the Chesterhope Bridge, completely isolating the Karamu Stream from the catchment. So it decreased from a catchment area of 2,000km^2 to about 500km^2. The Karamu Stream no longer receives flow from the Ngaruroro River and does not receive the gravel down the river so the Karamu Stream has turned into a muddy-bottomed stream.

After 1964 when there were flooding problems in the Heretaunga Plains, the stream was diverted to the existing course. That likely impacted on what we call the Clive River because it does not receive a supply of gravel anymore either (maps in slides 85 – 87). Prior to the 1964 diversion, the Tukituki River used to flow behind the river bank near the beach downstream of Clive at times (slide 86) and locals could actually paddle into Clive through that channel. The Tutaekuri River use to flow out via Meeane and down Georges Drive (Marewa) and out to the Ahuriri Estuary. It no longer follows that path. It was changed after the 1931 earthquake to share a common mouth.

Gary presented a summary of the drainage scheme and flood management values and who benefits from the scheme (slides 88 – 90). There are more details in the HBRC asset management plan which describes the drainage and flood control scheme in detail, what HBRC does and how HBRC manages it, including information on maintenance. A summary of land use in the scheme area was provided (slide 91).

HBRC has adopted a multi-value approach. On the Napier and Karamu Streams, a Stream Ecological Valuation (SEV) was carried out, which is a simpler science to apply but allows measurement of a lot of values and you can use the results to assess what might happen if different management approaches are taken such as shading of the stream and what the effects would be. The SEV can be used again after management practices are changed and will assist in determining whether it was successful.

A summary of the Karamu drainage area was summarised and the five key issues which create challenges: land ownership, maintenance access, erosion and slumping, excessive weed growth, and drainage issues (slides 93 – 96). In terms of maintenance, the discussion around shading is important.

In the RRMP HBRC requires a 6m access strip [refer to Rules 70 and 71] which is effectively from the top of the drain and 6m out. HBRC struggles in many instances really hard to obtain that margin and keep it. Sometimes HBRC can only get that margin on one side of the stream but where it is too wide HBRC needs that margin on both sides of the streams. HBRC is under a lot of pressure at the moment to reduce our setback but that would be counterproductive with what we are trying to achieve here, for example to put in shading we are likely to need more than 6m because HBRC still needs to get down there will machinery and there are trees there shading the stream.

HBRC has tried many methods for controlling weed but shading is a really good method. HBRC is currently looking at doing a small diversion in the Karamu Stream just above the floodgates and one of the options being considered is having a device that will capture floating weed so that HBRC can drag it off out of the way. There is still the challenge of disposal. In the Heretaunga Plains scheme area there are very little waterways managed to the west. Many of the drains flow east west which make them ideal for shading. The Karamu Stream flows more in the north to south direction and it is a lot wider and more difficult to shade. The Council owns very little of the land around waterways in the drainage scheme (slides 97 – 98).

In consideration of whether a drain dug out for drainage purposes is a stream or not, one of the difficulties is how do you separate it and everything that goes into the waterways ends up in the Karamu Stream, which includes all of the Hastings urban area and road run off, and farm drains. There is very little that does not end up in the Karamu Stream.

Gary presented on riparian management options and limitations and provided examples of waterways before and after channel modification/enhancement and use of shading (slides 99 – 103).

- An example was provided where a linear stream was changed to a meandering waterways and planted out (slide 99). Conveyance and slope are key factors. Conveyance is affected by the geometry/cross-section of the channel and roughness of the channel. The discharge is inversely proportional to the roughness, so the rougher it is the lesser the discharge. If you double the conveyance of a stream, you can plant out as much as you like on the sides without affecting the drainage.
- Another example of shading was provided by planting the bank with sedges, aquatic plants and bolboschoenous. Bolboschoenous is a good plant to use because it is a native plant, it grows about 800mm high, it provides some shading, it grows almost anywhere, it is salt tolerant and it dies off in the winter at the time when you want your drainage to be working the best. It's not a plant that will cause problems, it is easy to plant, and easy to remove if you need to (slide 100).
- Another example was shown of a drain on private property where part of a downstream reach has been planted with partial shading (slide 101). This is the kind of shading we may need to aim for. The plants are shading approximately half of the surface area and there is good shading underneath that will provide habitat for fish and some cooling of the water. This would be improved further if interspersed trees were planted as well. There is some loss of conveyance but the question is that a bad thing.
  Why we drain the land so fast and get rid of flood water as quickly as possible, then the next week we turn irrigators on needs to be considered. It is really valuable to hold water in the landscape and that helps to keep groundwater levels up and it helps with flow in the streams. Also, if we can keep water up in the catchment it reduces problems of flooding lower in the catchment. There are some benefits. We need to rethink about the way we drain our land.
- Another example was shown for a stream (flows in a north south direction) with shading on the north side comparing the shaded area to unshaded area (slide 102). Stream bed in the shaded area is clear in the summer.
- Another example was shown where shading the area is more challenging (slide 103). In this case, both sides of the stream would have to be planted to get adequate shading.

A summary of the Karamu Stream Enhancement Project was provided (slide 104).

1.4. Summary of presentation about Ground and Surface Water Model Pawel Rakowski

The spatial extent of the groundwater model was shown in a map along with the SOURCE model made up of over 130 subcatchments and each of the subcatchments has a separate model which feeds into the downstream models.

Two main reasons for doing the surface water modelling. Firstly, all of the upper catchment flow feeds into the rivers in the middle or the groundwater model. This is important to groundwater inputs. Secondly, the SOURCE model is being used to model transport of water and nutrients in the confined aquifer area.

MODFLOW GW flow modelling

Pawel presented on development of the Heretaunga Aquifer groundwater model (slides 113 – 132):

- Heretaunga Plains conceptual model:
    - Recharge into the aquifer is from rainfall recharge and river losses into the aquifer mainly from the larger rivers like the Ngaruroro River. Other rivers like the Tukituki River and Tutaekuri River also lose water into the aquifer. The flow was measured and estimated in many of the springs (work undertaken primarily by Thomas) and we can put a number on the amount of discharge from the springs, i.e. those discharges into the Raupare and Irongate Streams. The larger groundwater takes are the public water supplies and some industiral takes illustrated (size of the dots = volume of the takes). Each of the irrigation takes are relatively small but cumulatively form a large portion of abstraction.
    - A record of the water taken over the years was shown in a graph. There is not a good data set for water takes for irrigation because it is very distributed pumping from many different points. A water demand study was carried out to estimate the volumes of take. The volume of water taken for irrigation is highly variable but has generally increased over time.
    - The total volume of water abstraction is less than the volume of water allocated and the allocation is not fully utilised. This is important.
- Groundwater model setup (slide 119).
- Model calibration after the model was built (slides 120 – 123):
  Model calibration in simple terms is adjustment of model parameters to achieve a good match to the observation data. The simulated versus observed spring discharges show that the model is well calibrated. Using one well as an example shows that the model is able to model seasonal changes in groundwater level very well. Observed groundwater levels in another well as an example compared to simulated groundwater levels showed that the model is able to represent the overall reaction of the aquifer over a long time reasonably well.
- Preliminary model results after the model was calibrated.
    - Examples were shown of the drawdown produced by the current (actual) abstractions versus the maximum allocation was taken (maximum allocation is never actually taken but shown for presentation purposes). For current abstractions, in the main part of the aquifer the difference in groundwater level compared to no pumping is 1 – 2m. For modelled allocated abstraction, the water level drops significantly by another 1 -2m to 5m over the basin to 10m in the Napier area. Groundwater levels near recharge area do not drop as much.
    - Predictions show that when there is pumping, the discharge of springs to surface water is reduced in the Karamu Stream from about 700L/s to 600L/s (in comparison to if there is no pumping) and the amplitude of flow variation and is significant in the summer. The picture is similar for Raupare Stream, the discharge of springs to surface water is reduced by pumping from about 400L/s to 250L/s in recent years.
    - In the Ngaruroro River it is different in some reaches because it loses water to the aquifer. When pumping occurs there is more recharge into the aquifer because water level is reduced

and this increases the driving head that forces water into the aquifer so there is additional leakage from the river into the aquifer.
    - In areas of the Ngaruroro River where we observe that it gains water from the aquifer, predictions show that in natural conditions the river would always be gaining water but in current conditions when there is pumping the river switches from losing to gaining, consistent with observations of behavior of this section of the river.
    - We can also look at the overall change of the river contribution for example to the aquifer and this was shown for comparison of no pumping conditions, to current level of pumping to if full allocation was pumped. It illustrates that how pumping affects the system.
    - The long term aquifer response to current pumping was simulated to determine what would happen if we continue the existing level of pumping and whether the system is in equilibrium. Modelling of river leakage shows that the system stabilises almost immediately and this is good because it means that we are not mining water. Modelling of groundwater levels shows the same conclusion. The system is stable and there would not be additional drawdown if we continue pumping under the existing pumping levels.

- Modelling capability:

  Some of the modelling scenarios that can be run are simple and easy to set up within several hours. Other scenarios are more complex and require major work. Some scenarios were presented including (but not limited to):
    - Stream depletion zone delineation – test each and every location in the model and test how much connection each of the zones has to the rivers and streams. This is complex and requires a lot of model runs to do.
    - Impacts of abstraction strategies, i.e take the current abstraction and increase it by 10% and see what the effect is on the water levels and spring flows. Easy to set up and useful. Would become more complex if add different restrictions.
    - Security of supply for different strategies. More complicated because needs to link to the SW model to provide flows in the rivers.
    - Establish the allocation limit given an agreed effect on the system. We can run several scenarios, i.e. increase the current abstraction by 10% and see what the effect is on the water levels and spring flows. More complicated because requires multiple model runs.
    - Verification of how effective any restrictions on abstraction are on stream flow recovery, i.e. restrictions on irrigation takes based on spring flow and compare it to scenario where there are no restrictions and check what is the effect of the restriction on the river flow and whether it is effective in helping the stream or not.
    - Simulate managed aquifer recharge.

- Modelling limitations and uncertainties:
    - Actual water use – this is a serious uncertainty as we do not have the historic data for water use. Record keeping is important for future modelling.
    - Climate uncertainty – we cannot represent changes to pumping that may change with future climate.
    - Vertical resolution of the model – the model only has two layers and we do not have the resolution for all the possible application partly due to limited data availability.
    - Limited local scale detail – limitation to how complex the model can be set up. This model would not be suitable for some applications like very localised.

  However, we do have some certainties and it is a good overall tool.

1.5. Summary of model outputs in relation to MAR scheme

A SOE report that reported on trends during 1994 – 2014 found declining trends in the Roys Hill and Fernhill areas (slide 134). Well no. 15005 shows the most significant declining trend with an average decline of approximately 10cm/year. During calibration of the model, the model initially struggled to replicate the declining trends. An artificial recharge scheme was set up in the 1980s for the purpose of recharging the aquifer. The use of the recharge scheme between 1982 – 2008 was summarised (slide 136). The trend observed in another well (no. 10371) from 1968 to 2013 was illustrated in comparison to the timeline for the scheme. Whilst the scheme was in place the declines in groundwater levels were reduced and when the consent has a more restricted use the groundwater levels declined at a higher rate again (slide 137).

Calculations of MALF for the Ngaruroro River at Fernhill were presented in 2011 which took into account the IFIM surveys undertaken and worst case scenario for abstraction for the artificial recharge. HBRC has revisited the MALF statistics using naturalised flow from 1998 – 2008 (which is the same time period for which HBRC holds records for the artificial recharge scheme) and reconsidered the minimum flow taking into account IFIM. Naturalising the effects of groundwater abstraction found that the recharge scheme appeared to be effective at mitigating flow losses until the scheme stopped in 2008 and then there was an increase in flow loss from the Ngaruroro River to groundwater (slide 144).

Based on the new data the provisional MALF estimate is approximately 4,180L/s and provisional minimum flow for torrentfish is 3,860L/s (based on 90% habitat protection for torrentfish) This is really different to the 2011 IFIM report, which estimated MALF of 4,500L/s and minimum flow of 4,200L/s. This has important implications for the TANK plan change, i.e. if the minimum flow is lower the reliability of supply to water users is higher, and this will affect the economics assessment.

This is just one application of the modelling.

1.6. Summary of presentation about SOURCE Model

The model domain along with the each of the subcatchments (based on gauging catchments calibrated to) was illustrated. Each subcatchment is a separate model. Within those models it can be divided into functional units that can be based on factors such as land use, soil type, slope. Currently the domains are largely based on land use (slide 1). This is a powerful tool when looking at different land management options and mitigations. The catchments can be broken down to look at the impacts of different options at any point in the river system.

The purpose, aspects, capabilities and limitations of the model were summarised (see slides 2 – 3 and 6). Rainfall gradients and land slope, as examples of parameters used in the model, were illustrated (slides 7 – 8). The model operates on a daily timestep and this is really important because impacts on streams can be driven by events that occur over short timeframes such as erosion and storms. The model is well calibrated with flow between 100th - 40th percentile of probability of flow exceedance (and diverges at higher flows) (slide 9), which provides confidence that the tool can be used for water quality and quantity limit setting.

Once the flow aspect of the model is running, scenarios can be tested, i.e. the reliability of flow statistics when the maximum volume of water allocated to consents is abstracted using different minimum flow limits. An example was presented showing the average number of years the takes would go on ban (slide 10) and how many days the takes would go on ban (slide 11). As the minimum flow increases, there is an increased frequency of bans and decreased security of supply. A reporting tool will be built into the model so that anyone can use it and it will be provided to HBRC.

For water quality modelling, a graph was presented showing total nitrogen load. Nitrogen filters through the soils and into the unsaturated zone reaching the groundwater table, which is effectively driven by wetness and dryness of soils or percolation. In the Source model there is a soil-moisture water balance model which drives the rainfall run off response. We have used the percolation component of that model as a proxy for catchment wetness index and therefore transformed the annual load model into a daily load. So the value from Overseer (green line in the graph) is changed (effectively becoming the red line) which is then brought into the Source model. That is attached to the groundwater component of the Source model then that gets mixed with the surface run off and gives a water quality outcome in the stream (slide 12).

Water quality is different to water quantity in that it is not typically measured automatically and spot samples are taken. The model is doing a good job of attempting to join those dots together, for example total nitrogen calibration (shown in slide 13).

To transfer an Overseer load into something observed in the field requires between 75 – 90% reduction. That indicates that Overseer is putting out a value beneath the soil zone that is significantly more than what is observed in catchments in NZ. Overseer does not account for denitrification that occurs in the catchment. Water moves down through the profile into the reduction zone, and in this zone nitrogen is stripped out. The amount of nitrogen observed in the stream is significantly less than what remains in the soil. This has significant implications for land management.

Simulations have been done to find out what happens when the load in the catchment is increased and decreased. Ngaruroro River at Whanawhana was shown as an example of the scale of change of total nitrogen concentration in the stream as a result of loading (and land use) changes (slide 15). The model can help to make decisions around what the outcomes of land use changes might be in different areas.