会議資料２

REPORT

The validity of planned flood-control measures in the Kuma basin

Kumamoto Prefecture, Japan

Observations by Dick de Bruin,
based on a visit to the Kumamoto Prefecture, July 2008

August 2008

Contents

Note:
The blue text blocks in the report refer to relevant conclusions and recommendations. They are taken together and presented in paragraph 9 again.

The validity of planned flood-control measures in the Kuma basin.

1 Introduction.

On the Southern island of Japan, Kyushu, one of the Prefectures is Kumamoto. Within that Prefecture, the river basin of the Kuma is located; its main tributary is the Kawabe.
Since ages, there are major flood problems during the annual typhoon season along the banks of this river system. More in particular, regular flooding occurs in urbanized and populated centres (e.g. the city of Hitoyoshi) and adjacent land (e.g. agriculture land), sometimes to be characterized as social disruption, sometimes even as a disaster with severe damage to capital investments (buildings, industries, infrastructure).
The set up of the managing organization of the Kuma is according the Japanese system of River Administration. For a Class A river, the national government, represented by the River Bureau of the Ministry of Land, Infrastructure and Transport (MLIT) is the first accountable organization. The managing authority of the greatest part of the main tributary, the Kawabe, (from its confluence with the Kuma till about 15 km upstream of the planned site of the Kawabegawa-dam) is also Class A, so MLIT is first accountable as well. For its portions (headwaters, etc.) that are not directly managed by the government (Class B), the governor of Kumamoto prefecture is accountable, under delegated authority of the minister. In the mid 1960s, the national government (MLIT) has proposed the building of a major dam in the Kawabe, with the purpose to store a substantial part of water during the typhoon season to minimize the actual peak discharges going down the Kuma, and thus minimizing and even controlling the severe damage as caused regularly by torrential floods. The plan has raised initial opposition by the village Itsuki, whose central area -Touji- would become submerged if the dam was to be constructed. However, the village Itsuki, the national government and Kumamoto prefecture reached an agreement in 1996 on the construction of the Kawabegawa dam *(note: further in this report mentioned Kawabe dam).*
As late as 2003, opposing groups were able to come up with a detailed alternative plan. This has triggered ongoing discussions on this dispute since then. It is the main reason why a decision on the further development of fundamental flood control schemes in the Kuma basin, and more in particular in the valley of its main tributary Kawabe, has not been taken yet.
The recently (April 2008) new elected Governor of the Kumamoto Prefecture, Mr. Ikuo Kabashima, has taken the initiative to clarify the essentials of the ongoing disputes, so that in September 2008 a clear decision can be made (on Governor level) about further (planned) actions to be taken to achieve a standard safety in the Kuma valley during the passage of a design flood as can be expected once in 80 years for the main part of the river (e.g. the city Hitoyoshi), and once in 100 years for the downstream end (the city Yokoishi).

To achieve a well documented advice before taking a decision in September, a Knowledge Assembly has been established with eight respected Japanese senior experts on various fields. The Assembly has planned various meetings in 2008 to be able drafting an independent and well documented advice for the Governor of Kumamoto Prefecture. In this framework, a field visit was planned for a plenary meeting in the field, July 11-13. In his letter of June 1st, 2008, the Governor of Kumamoto has approached an independent expert from the Netherlands, Mr. Dick de Bruin, for joining the field visit and observing the planned Knowledge Assembly meeting and discussions; by August 4th, 2008, a report on his observations is awaited.

2 General description of the Kuma.

Well prepared and sufficiently detailed documents have been made available, composed by the staff of the Kumamoto Prefecture River Division. During the visit to the Kuma basin, July 11 - 13, many discussions have been held, both in the field and in offices, with experts representing the staff bureau (River Division) of the Governors office. On various occasions, meetings and discussions have been organised with people and officials in the basin, both representing opposing and supporting groups. Arguments were heard from both groups during presentations and during direct discussions with the Knowledge Assembly members. Through an independent well skilled professional interpreter, Mr. De Bruin could easily follow the discussions in Japanese language, and could also participate if opportune. Site visits were well organised during three days. The Kuma (stretch between Ichifusa dam and Yatsushiro city) and Kawabe (stretch between confluence with Kuma and Itsuki village) have been visited.

It was generally found that the Kuma is of modest size, with its major channel(s) still in natural condition. The river is dominantly of a non-alluvial type, many large rocky outcrops in the riverbed and along the banks have given this feature of nature a wild and beautiful stage. Although through ages hundreds of thousands of people have lived and worked in the river basin, its waters are (still) not polluted and therefore offer a healthy habitat for flora and fauna. The population in the basin earns utmost credit for that. The river is recognized as one of Japan most attractive natural streams. Due to its wild and turbulent nature, tourism e.g. rafting at particular stretches has developed. In the foot hills of its headwaters, there is the Ichifusa dam, functioning first of all as storage reservoir to flatten the peak flows coming down the headwaters of the Kuma basin during 'tsuyu typhoons' with heavy precipitation.

In terms of integrated water management, not all sectors as usually present wherever, are using water from the Kuma, e.g. there is no shipping of cargo and passengers (except rafting); irrigation is mainly limited to the upper (upstream Hitoyoshi basin area) and lower (downstream Yatsushiro plain area) stretches; power generation is minor and is restricted to the Arase and Setoishi dams; excavation of clay/sand/gravel/rock is limited or even no longer opportune; process water for industries is mainly restricted to the stretch just upstream the short tidal reach, downstream the Yohai-zeki dam. Tourism, e.g. rafting and biking, is concentrated along certain stretches.
As far as the aspect flood control is concerned, the following general observations are relevant: the ratio between minimum discharges (dry season) and maximum discharges (flood season, heavy precipitation) is rather extreme. It was observed that presently there are severe flood control problems along the Kuma in all characteristic stretches. The most striking flood control problem is found (no doubt!) at Hitoyoshi city, just downstream the confluence with the main tributary, the Kawabe. All other flood related problems in the basin are (technically) minor when compared to the actual Hitoyoshi problem. In this respect it must be said that the ongoing mitigation measures on buildings in small districts/villages, as noticed along the stretch that is characterized as the narrow 'intermontane valley', are remarkable effective and have been implemented so far without too many difficulties. The stability problem of the Hagiwara levee along the right bank just upstream Yatsushiro city still has to be solved with additional (strange enough disputed!) methods. The dispute here probably is caused by wrong-understanding: actually the proposed measure is not determined by overtopping during design floods, but is determined by the fact that the earthen body of the levee shows instability problems, and because the adjacent land behind the levee is far lower than the (flood) water levels, in fact the entire area of the city Yatsushiro is flood prone. Therefore

urgent repair, strengthening and adaptation of the cross profile of the flood protection levee along the outer bend is definitively needed.

A general conclusion on the Kuma is the following: the fortunately still unspoiled nature of the river, flowing in a beautiful mountainous landscape, has created a visible balance between economy and ecology, prosperity and welfare. First of all the population and residents in the river basin, now and in the past, earn utmost credit for this.

3 Determination of design flood(s) in the river basin.

Given the distribution of population and invested capital (buildings, offices, infrastructure) behind the flood protection system along the river, it was earlier decided to take a once in 100 year flood as standard for flood protection along the downstream stretch (from Yokoishi control point to the sea), and a once in 80 years design flood in the rest of the basin. Of course, these safety standards are decided officially by the public sector in Japan, as such they have to be respected. However, it must be said that when comparing this with usual safety standards as applicable elsewhere in the industrialized world for areas behind flood protection systems with considerable population and huge capital investments in flood prone zones/land, a 1:100 respectively the 1:80 years safety standard is rather low. This safety standard in fact covers only the time span of about one generation, which is not really safe!

Usually, a design standard on maximum flood discharge is determined by statistical analysis of time series data. In hydrology and in hydraulics, there are more scientific approaches and models used for this. Since recent decades, in both fields technical and scientific progress and developments have been numerous, they still continue. Each model (theory) as presently used has its own specific application, it is related to the character of the basin concerned (soil properties, vegetation, urbanization, and the like), the precipitation and evaporation as common in the area upstream the measuring point and others. Of course, meteo- and hydrology experts in Japan know the best what models suit the most for typical Japanese conditions, also in the Kuma catchment. In the documents on the Kuma basin as provided, many data are given on measured top discharges in the past and more recently, at fixed measuring points. With statistical analysis they are extrapolated to the desired level of safety standard, giving the (calculated) design discharge, or basic flood discharge, at those locations. Of course, the way how via statistic extrapolation the basic flood discharge has been determined 40 years back and more recent, differs. It is reflected in the two approaches *'Construction Work Implementation Basic plan'* and *'River Development Policy'*, one of the reasons why in the calculated basic flood discharges of both approaches some difference exists. Also the alternative calculations, as done by opposing groups, show some differences in the outcome of the extrapolations, determining the basic flood discharge at some fixed measuring points. But all together, the determined basic flood discharges generally show at least the same order of magnitude.

Often, during the passage of a high peak flow (still under the level of a basic flood discharge), measurements are done in the field to calibrate the extrapolated part in the applied statistical approach. Then, with velocity measurements in the cross sections, peak discharges are determined and checked with the (extrapolated) stage/discharge curve in the top segment, if possible and opportune. Suchlike field measurements are only feasible in cross sections where the current distribution in both the vertical (depth) and the width of the channel are rather uniform. Fact is that the non-alluvial character of the Kuma is shown by many rocky outcrops with random shape, the channel is utmost irregular in both vertical and width direction.

Thereby, the average gradient is rather high, 1:300 to 1:1000. As a consequence, the current velocities in the cross sections at measuring points and the turbulence during the passage of high discharges are extreme high and turbulent. Achieving accurate measurements under these circumstances is hampered severely, the more so because even hydraulic jumps can occur and debris (trees) can damage instruments. It is understood that practice has shown that the average currents at the Hitoyoshi measuring point can vary from about 3 to even 5 m/s. For further rough calculations hereafter, an average velocity of 4 m/s is assumed.

Having seen all data and statistical approaches on determining the basic flood discharge, there is no reason to assume that conclusions as taken for the design peak discharges (being the basic flood discharges 1:80 and 1:100) are fundamentally wrong. That's why hereafter, the 7,000 m3/s at Hitoyoshi measuring point and the 9,900 m3/s at Yokoishi measuring point, are considered being all right and give no reason for disputes. The more so because slight differences in outcome in fact mean that the actual safety standard will be either a bit lower or higher, which is in fact not really important for the safety in practice as long as that real standard is applied consistently along the entire river.
Also, the duration of the calculated basic flood discharge is determined in the documents as 12 hours; this is based on: a) calculations of time of concentration in ten major floods as recorded in recent years, b) correlations between recorded peak discharges and rainfall duration, and c) recorded duration of intensive rainfall. The conclusion, that the duration of a basic flood discharge at Hitoyoshi measuring point is most probably 12 hours, is supported.

Another crucial discussion point is the actual discharge capacity of the major channel at Hitoyoshi during the passage of peak flows, more in particular during the passage of a basic flood discharge. Objectors and designers assume different figures, in addition there is a dispute on the matter of freebord.
It is a fact that the bottom pattern of the river is extreme irregular due to its non-alluvial character, and that the irregular and definitively non-consistent influx of additional discharges from the three small tributaries in the Hitoyoshi area (Yamanda, Mae, Mune) to the Kuma can still cause non-permanent extra local backwater effects, in addition to the already extreme turbulence that will occur on that moment. Therefore, it certainly cannot be predicted with reasonable accuracy what precisely the actual discharge capacity of the main channel during the passage of a basic flood discharge will be. Also freeboard under the crest of a flood protection system cannot be guaranteed. One must guess, and the way how the 'MLIT-designers' have approached this matter shows that they opt for a *conservative approach*, while the objectors expose a more *optimistic attitude* by assuming that considerable more discharge can be taken by the channel. May be one of the guesses is right, may be the actual truth is somewhere in the middle, anyway nobody can say and predict with reasonable certainty how much it will actually be at the moment a basic flood discharge will pass. Still, a conservative approach includes that more water must find its way through the down town area of Hitoyoshi city, which will set a more realistic standard and scenario for additional protection measures in that area during the passage of such an extreme flood. For this urbanized area it is better that anticipation measures are based on higher discharges instead of taking too low figures as standard, so that unavoidable damage remains at least as low as possible.
Hereafter it is assumed that the major channel at Hitoyoshi measuring point can only take 4,000 m3/s during the passage of a basic flood discharge, the rest (3,000 m3/s) must find its way over the banks and adjacent urbanized land; thus following the conservative approach.
Actually, in the recent past the down-town urbanized area of the city Hitoyoshi has become submerged regularly, leading often to disruption and severe damage. This is exactly the reason why more fundamental (and sustainable) flood control measures in the river basin are

needed, the more so because due to expected climate change the situation still may get even worse in the future. And this last issue, climate change, is more and more an important but additional design condition when new infrastructure must be built. In terms of sustainability, its lifetime (proper functioning as originally designed for) must still remain guaranteed over at least as many years as in the old days!

4 The main flood control problem.

There must be found an acceptable flood control solution at Hitoyoshi for controlling the passage of the 1:80 years basic flood discharge of 7,000 m3/s, in particular for the remaining 3,000 m3/s that cannot be drained through the natural (wild) river bed. Or more precisely: it concerns the control of about 3000 (m3/s) x 12 (hrs) x 3600 (s) m3, or 130 million m3 during the passage of a severe tsuyu typhoon storm with heavy precipitation in the entire river basin. Most probably, at the beginning and at the end of the 12 hrs period, the peak discharge will be slightly lower than 7,000 m3/s by following a gradual building up and a gradual decline around the top of the peak curve, so in fact a solution must be found for storing a volume of about -say- 110 million m3 floodwater, generated within 12 hours upstream of the measuring point at Hitoyoshi, in the Kuma basin.

A rough calculation learns the following: given an average current velocity in the main (wild) river bed of 4 m/s during the passage of a peak flow at Hitoyoshi, for an amount of 3,000 m3/s an additional wet cross section is needed of about 3,000/4=750 m2. It must be noted that in general deep and more narrow channels have more discharge capacity than shallow and wide channels, because in the mathematical description of surface run-off the discharge Q is related to depth h(power 1,5). So, theoretically and technically, the additional theoretical 750 m2 in the cross section can be achieved with various ways of combinations of extra width and depth. This extra capacity in the cross section has to be dredged/blasted/excavated, reason why one may expect that the environmental impact of these measures will be substantial. In addition there will be another claim from the tourism sector, however when comparing such a claim to the real flood control problems at Hitoyoshi, the priorities are utmost clear.

From an engineering point of view there are basically five options to control the amount of surplus water (up to 3,000 m3/s) at the critical Hitoyoshi measuring point:

a) deepening the riverbed entirely over various meters;
b) widening the riverbed substantially over some hundreds of meters;
c) a combination of a) and b), offering at least 600 to 900 m2 additional cross section of water, depending on the opted combination of extra width and depth;
d) manipulation of the time period wherein the surplus discharge will pass, anyway after the 12 hr period of the passing of the peak flow;
e) a practical and feasible combination of a), b) and d).

Ref. a) and ref. b) are practically impossible because in both cases the natural riverbed will be totally disrupted; the environmental impact cannot overseen now, but it will be substantial. Ref. c) will also have a severe (environmental) impact, however with a critical combination of chosen additional depth and width the damage may be less (but perhaps not under control!). So the remaining practical option is ref.d): manipulating with dams the downfall of the surplus discharge in the river basin, upstream Hitoyoshi, together with additional channel adaptations in depth and width at that place.

Note: it must be said that the ref.e) option is the most difficult and complicated one in terms of effective flood management control at the time it is really critical and needed. Therefore it must first of all be considered as a *theoretical option. That's why ref.e) will only be explained at the end of this report (paragraph 8), after all other issues in relation to the flood control problems in the Kuma basin have been dealt with.*

5 The creation of additional storage in the basin, upstream of Hitoyoshi.

Storage can be achieved with the creation of a single big or with few smaller dams. Finding a suitable location for building a dam is determined by geological criteria and by the required capacity of the reservoir(s); in this case storing about 110 million m3 (see paragraph 4) over a certain period. A proper inventory of the entire Kuma basin upstream Hitoyoshi shows that in fact the only (technically and economically) feasible option for building one or more concrete dams is present at few particular locations in the major tributary, the Kawabe. A further analysis of the Kawabe sub-basin learns that in fact there is only one location feasible for building one big dam, creating a reservoir with required capacity. This potential dam-site was already determined in the 1960s. Thus, from an engineering point of view it can be stated that the planned 107 m high concrete dam site is at the one and only suitable place. In this respect the following remark must be made: in case the creation of also other smaller reservoirs is opportune, so if the building of smaller (masonry or earthen) dams is at least technically feasible in the Kuma basin upstream Hitoyoshi, most probably the crest high of the planned Kawabe dam can be constructed lower.

Because the building of the planned Kawabe dam will have environmental impact, at least substantial mitigation and compensation measures are needed. They must be (further) elaborated after the decision has been taken whether such a dam will be built or not. However, before such a decision will be taken, already a first inventory can be made of suitable and sustainable mitigation measures, focusing on minimizing negative environmental impact of such a measure. It is strongly recommended that a special report is prepared on all mitigation/compensation measures that are foreseen when a dam in the Kawabe will be built. These measures must not only be restricted to the area at the planned dam site and the upstream reservoir to be created, but must also deal with other mitigation measures downstream the Kawabe and even in and along the Kuma further in westerly direction.

An alternative option, as suggested by an opposing local residents group, to inundate nine specific parcels of fertile land during the passage of a severe flood, is in fact in terms of adequate flood control not feasible. The offered total capacity is far too low: maximum about 15 to 20 million m3, although in the papers as presented by the opposing group it is mentioned that the capacity should be around 29 million m3. The difference between suggested and real capacity is caused by the fact that the proposed basins are located in adjacent land directly behind the flood control levees where their surface must also be sloping down, parallel to the average height of the riverbed. If these parcels of land are becoming inundated by purpose as suggested, the stored volumes of stagnant horizontal water in those separate basins will show a triangle and not a rectangular shape in the vertical. And: around each proposed basin a new flood protection levee is needed with horizontal crest from the inlet point (plus some freeboard). These additional levees must be built on private land, so land acquisition will be expensive when opting for this alternative. It is noticed that these additional costs are also not taken into account in the proposal of the opposing group(s). Also in terms of effective and practical flood management, a system of nine separate basins on private land can only work if the river managing authority will always have a complete say on the moment where, when and how all inlets must function during the passage of the peak flows (not only the basic design discharge!), and when regular maintenance on the entire system is needed (and done!) at times if there is no flood at all but the fertile land is used for farming.

Taken all these aspects together the conclusion is that the proposal on the creation of nine storage basins in the relative flat plain along the Kuma upstream the confluence with the Kawabe, as a full alternative for the planned Kawabe dam, is not realistic. However, the use of these storage basins could be one of the elements as part of ref.e) indeed (see par.8).

6 Climate change and sustainability; pros and cons on the planned Kawabe dam.

In fact, in the present ongoing nation wide disputes in Japan on the pros and the cons of building a Kawabe dam at the planned site, the concept of the sustainability of the measure has not yet been discussed properly. In his respect the following aspect is of importance.
In case that due to climate change the precipitation (during typhoons) will further increase during the next decades, it is crucial that a dam to be built remains flexible enough in its engineering design and functioning, to withstand an increase of influx in the next generations as a possible consequence of climate change. That extra influx is above the design capacity of 133 million m3. Under those possible circumstances in the far future, the extra influx in the reservoir due to climate change can be released (in theory) via a tunnel (with a diameter of about 10m), to be drilled over a distance of about 15 km in westerly direction, from the created reservoir just opposite the village Itsuki. For now, the suggested diameter (10 m) is just ´a guess´, it should at least be sufficient to compensate an extra influx in the reservoir due to possible climate change. A further elaboration of such an (expensive of course) extension in the long term is not appropriate now. However, it should be noted that with such an option as fall-back position, the sustainability of the planned Kawabe dam is guaranteed for generations to come.

And what about a situation if no additional storage capacity in the river basin upstream Hitoyoshi (a dam in the Kawabe) will be built? Then, an alternative must be found for the main flood control problem in the valley, the situation at Hitoyoshi down-town.
No doubt, Hitoyoshi city needs a dam for getting at least a reasonable safety against a basic flood discharge as occurring once in 80 years. But still, such a safety standard for about 100,000 people can only be characterized as being reasonable, definitively not more than that.
In case there will be built no dam in the Kawabe, the safety against flood protection of the Hitoyoshi area remains below every reasonable standard that should be expected for an urbanized zone in an industrialized well developed 21st century society. Then, in the worse - but realistic!- case, the entire down-town area better can be demolished and flattened, to create more (local) discharge capacity in the riverbed. But then still in more downstream direction severe flood control problems will increase, urging again new technical provisions that remain disputed for first of all environmental reasons.
Under those circumstances, the aspect 'safety for the population along the banks of the Kuma' will quickly become of secondary importance. So, again a discussion period over many (40?) years can be expected without any progress on implementing adequate and sustainable solutions in the entire valley. Then together with the already ongoing planning- and discussion period as occurred since the last 40 years, the preparations of building a (planned) dam will have taken a time span as long as 80 years, being the safety standard for the design flood. At least, that will make the statistical analysis very easy(!).

7 River engineering aspects.

Based on the documents as made available during the field trip and the discussions as held at various sites, some specific remarks on river engineering aspects are presented hereafter. The raised issues are presented in the sequence of the elaborated subjects in the earlier mentioned documents, as provided during the filed trip.

A The Hagiwara levee.
It is obvious that some severe stability problems occur during the passage of peak flows. The proposed measures with the purpose to strengthen the levee will definitively improve the situation. May be with some additional dredging in the inner bend of the main channel, some extra discharge capacity can be achieved in the cross section. During the field trip it was noticed that the opponents don't have a clue why the proposed measure is actually needed. So, in discussions with opponents of the entire plan, it must be made clear that overtopping is no problem at all, the works are only needed because of severe stability problems. And, in case the planned dam in the Kawabe will be implemented, it will decrease the peak levels at Hagiwara because 3,000 m3/s over 12 hours will be stored in its reservoir and, after the passage of the basic flood discharge, gradually be released. This will also have a positive impact on the levee's stability.

B Erosion/scouring of the channel bottom during floods.
It is said that during the passage of higher discharges, when the currents will increase, some scouring effects lead to the removal of gravel and other small fractions of bottom material, thus hampering the number of spawning zones for freshwater fish. If that really is a severe matter, the dump of gravel should be considered after the passage of floods at those critical areas. This gravel dumping can be considered as some kind of mitigation measure, and must be repeated after again a next flood has passed. The building of a planned dam in the upstream basin will moderate the peak discharges, so also the maximum currents; as such it will have a positive impact on the scouring process.

C Execution of river training works (bottom, lining, channel, etc.)
The execution of river training works in the main channel of the river is restricted to the low water season. Then, at most places the channel is very shallow, so even with equipment as normally used for executing works on land (bulldozers, grab cranes, shovels, etc.) it must be possible with some minor adaptations at the work site, to use this regular equipment also for river engineering works. Then, special equipment on board of a floating pontoon is not necessary, which will save a lot of logistic problems when mobilizing the machinery (see the mobilization of floating barges/pontoons with crane on board during the recent works at Hagiwara levee from the waterside).

D Water use in the downstream basin; extraction points.
For drinking water industry, process water for industries and supplies for agriculture, fresh water is used in the basin at various places. For this, extraction points are needed. The manipulated peak discharges will not have a negative impact on these activities, only regular maintenance at extraction points remains necessary.
A special point of attention is possible salt intrusion in the brackish and salt water zone via the subsoil under the levees to the adjacent land. As everywhere in the world where productive agriculture industry is located nearby salt and brackish coastal waters, this aspect needs continuous attention. Because reservoirs in the upstream basin will gradually release discharges after the passage of a flood, during the low water period (dry season) discharges

will increase a bit. So, if there will be an impact it will work out positive and not negative in this respect.

E Fishways along existing weirs.

It is said that the technical condition of some fishways ('fish-ladders') has deteriorated in recent years, due to several reasons. It is not expected that the situation as such will change when the planned dam in the Kawabe river will be built. Also fishways need regular maintenance, these (standard) works are not fundamentally hampered by some changes in the regime of the river as caused by dam-building.

F Measures against (potential) pollution.

Although the Kuma system is not (yet) polluted, still the river management must be (and remain) alert on the quality of the surface water. Locations where (potential) pollution occurs or may occur, must be examined carefully, and measures must be planned in case pollution really will become an issue. Apart for reasons of public health, this is due to the fact that the financial aspect of water pollution prevention measures is a determining factor for daily water (integrated) management. Policies are needed to guarantee sufficient control on these aspects in the near future, and related to that additional legislation/supervision/enforcement must be planned in case polluting developments will become noticeable. It even may urge the need for institutional reform, when developments elsewhere in the world on the matter may serve as lessons learned for Japan as well (!).
Specific attention is given in the documents to turbidity of flushed water volumes, as experienced from the Ichifusa dam. It was suggested that the experience should be a precedent for other reservoirs to be created in the basin. As long as the suspended load is not polluted, in fact the turbidity usually means that fertile fine sediment will settle in the fields, and that is usually not being considered as a problem.

G Three dams in the midstream area (Setoishi, Arase, Yohai-zeki).

It is understood that the actual situation is as follows:
The Setoishi dam has been constructed (by J power) for the generation of power. This function will remain.
The Arase dam has been constructed by the Enterprise Bureau of the Kumamoto prefectural government, and is also designed for power generation. Although there was a plan to dismantle this dam, the plan was frozen on governor level. At present, the dam's future role is being reviewed to continue power generation there.
Yohai Zeki is a dam for using river water for agriculture, industrial production and drinking water. There is no plan to dismantle this dam.
So, in fact the three dams will remain there for the time being at least, but the far future of the Arase dam is uncertain. Taking a look at the longitudinal profile of this river stretch as presented in the documents, there must be some backwater impact of these structures during the passage of peak discharges. Also during the passage of the basic design discharge, there must be a backwater effect noticeable. This may have consequences on the design water levels just upstream, along the banks. It is not known if the additional works as planned and executed (landfill, lifting of structures, etc.) in the various districts nearby, are also designed for those extra backwater effects as well. Also the rail and road infrastructure along the banks just upstream those dam sites may be hampered under those extreme circumstances. It is recommended to look at this matter, just for being sure that at least the landfills etc. are not 'under designed'.
Upstream of those three structures, there must have been settled finer fractions of sediment. During a peak flow, that may be partly washed out and deposited further down. This issue,

and its possible impact in the future, has to be analysed further. Due to the dominant non-alluvial character of the river (many rocky outcrops along the banks and on the bottom), a reliable prediction of possible bottom erosion on the long term is not possible, but of course expectations can be given. Measures must be widely discussed. Implementation of required measures will be first of all a matter of 'trial and error', in his respect.

H Land raising in various districts with scattered population.

The application of horizontal landfill in the narrow gorge, behind the levees, is supported. On this new horizontal land, housing is re-settled. It is recommended to watch effects such as subsidence and compaction, while a proper drainage during the wet season remains crucial. It is observed that at some of those locations, new bank protection is of a closed continuous type of settled flat stones and concrete (elements). It is not noticed if proper filters (geo-textile) have been applied everywhere between the stone revetment layer(s) and recent landfills. If not, it can be expected that some parts of the closed revetments will become undermined by washed away earth material due to heavy showers and poor drainage. This can cause a complete collapse of the revetment system, examples are shown in the documents, e.g. at the confluence with the Yamada river (page 12, first bunch of documents).

Also at many locations along the banks small parts of (very) local revetments have been seen where the stones and concrete elements have been slipped away from their original position. This may have been caused by the same reason, but then on a smaller scale. Anyway, none of those damaged constructions make any sense any longer, so they should either be repaired or removed. Before doing so, an inventory from the waterside is recommended, just to find out where those damaged (small) constructions are precisely located. As such, this inventory and related restoration works can be classified under mitigation measures; it will prevent a further 'visible landscape pollution'.

I Bank protection systems and levees.

Because the land fill zones are protected with a closed system of smooth revetments, at least at some utmost visible places, it is questionable if such technical designs are preferred by the population and by environmentally oriented action groups. People are living there behind a solid wall of stone and concrete; one may wonder if they appreciate that. Therefore, it is recommended to look at least for construction types of revetments that are well known as environmental friendly and sustainable under the circumstances. Ample literature exists on the subject.

Levees are artificial (man-made) constructions. Their construction may decline in due time, reason why regular inspection and maintenance is (and remains) urgent. Degradation is caused by subsidence, compaction and just damage, while also at transitions often failures occur and repair is needed. Therefore at least regular planned checks are needed.

During the passage of flood discharges, it can be expected that finer (loose) fraction of bottom material such as gravel and sand will be washed out. This has been experienced during recent various floods at the time they came along. It has led to the degradation of spawning grounds for migratory fish and to changing patterns of white waters for rafting: thus for tourism. Of course, with regular mitigating measures such as regular dumping of gravel after some years, those effects can be compensated. Because the river is mainly of non-alluvial character, it is not expected that high peak flows, partly released/flushed from the planned dam thus rather aggressive because a lot of natural sediment will have stayed in the reservoir, will erode substantially the river bottom and even lower it over the entire width and length in the far future. See also point I, above.

However, there is another aspect to be watched carefully due to this mechanism of fine fractions being washed out. That has to do with the stability at the tow, under water, of extensive lining systems (revetments) along land fills and housing thereon in the middle reach. In case there is no proper filter (geo-textile) in the construction of the revetments, it may be possible that the tow will finally become unstable and the above laying revetment will collapse in due time.

J Degradation of rock material, when exposed to air.
This is a crucial issue, developments must be followed and watched carefully. In case instability problems threaten bridges (pillars and abutments) and revetments, direct corrective measures are recommended. Further coordinated research on this matter is recommended.

K Marking flood levels in urbanized areas, as memory sign.
Some modest marking of recent high flood levels has been noticed in Hitoyoshi down-town area. A suggestion: just to mobilize people awareness and keep people alert, at least the marking should be intensified, and executed in a more visible and appealing way.

L Irregular channel profile in the cross section.
It is noticed that at some places, e.g. opposite the down-town area of Hitoyoshi where the wet cross section profile during the passage of floods is utmost critical, rocky island(s) exist with even some bank protection systems on modest scale. The question is if such considerable hydraulic obstacles cannot be (partly) removed, just to lower the hydraulic resistance.

M Progress of construction works on the planned Kawabe dam.
During the field visit to the proposed dam site and the discussions in the town hall of Itsuki village, it was said that even the *new made roads* in the area are too curving and have restricted free profile for traffic related to tourism etc. This is remarkable, because the many new constructions must have been designed and based on nowadays standards in land traffic. Most probably, a better tuning with the requirements in the Itsuki village is opportune. Furthermore, it was mentioned by the mayor that in fact there will be *no tourism potential* on the lake as will be created by the planned dam, because the annual level fluctuations will be too big for adequate and frequently used go-down structures and jetties. This issue should be further discussed and elaborated, because the renovated/restructured Itsuki village really has a socio-economic problem when working and planning for the future of its population.
It was mentioned also that the number of *mud slides* on the steep slopes of the Kawabe valley increase. This is supposed to be caused by the increasing number of deer in the valley, grazing and destroying the low vegetation between and under the trees. If this is really a practical and increasing problem, the influx of sediment in the reservoir behind the planned dam will increase, so there may be needed some adaptation of the planned (sediment) flush capacity from the reservoir to the valley downstream of the planned dam on the longer term. In this respect, more options are feasible, the flush system as designed for the dam should be reconsidered, just to anticipate on a worse scenario as not yet foreseen and anticipated on.

N Flush programmes of the stored volume behind the planned Kawabe dam.
The documents show how the flush programme of the stored water volume in the reservoir will be practised. It is clear that it will be mainly applied for achieving adequate flood control further downstream in the Kuma basin. Since the generation of hydro power has been cancelled, no other major water use is planned, apart from some quantities of water that will be used for local irrigation along the northern side of the Hitoyoshi plain. That will be implemented via a combination of tunnel and pipeline. Precise data on this water use plan have not (yet) been shown. However, also (planned) tourism in the lake should be considered as a (potential) user of water, requiring stable levels as much as possible in the season!

O Mitigation measures; rehabilitation and restoration schemes.

In the documents some planned mitigation measures are mentioned, focusing on aspects such as rehabilitation and conservation of mudflats in the estuary and of brackish water environment in the lower reach, the rehabilitation of rapids and stream pools lost due to the excavation of gravel in the past, and the restoration of fishways. Furthermore, rehabilitation and conservation of forests in the basin is planned, as well as habitats for rare species. A clear distinction is made for all such measures between the estuary, the lower reach, the middle reach, the upper reach and the headwaters. During the field trip, there has been hardly any discussion on these issues, although it is believed that in particular this category of measures has taken specific attention by opposing groups. It is expected that many of the internal discussions by the scientific members of the Knowledge Assembly will also focus on these issues. During the visit and discussions however, those discussions have been hardy observed. It is recommended to elaborate on these issues in a special (accessible for outsiders) report, in a way that protests etc. as heard during the last years are reflected in the measures to be planned and finally to be taken and implemented. In addition, the planned conservation measures to be taken for tourism and natural landscape should be taken up in such a report as well; a main issue in this respect is stabilizing the minimum flow during the dry season; this may extend the length of the tourist season (being an important socio-economic factor!).

P Bridges crossing the main river, and other infrastructure (road and rail).

Because there is no inland navigation on the river, many bridges have been built with small spans and rather low clearance. During extreme floods, turbulent water masses come close to the underside of the bridges, debris might even become stock at those structures, leading to extra obstruction and hydraulic resistance. Then, structural damage becomes a real danger; if so, it can be the start of a damaging chain reaction nearby, along the banks and on shore. The documents as provided show research data on this matter as of 1999. It is recommended to make an updated inventory on the most critical situations. Also an inventory should be made of the costs needed to adapt at least at some locations the construction type of a bridge. A renovation plan on the medium and long terms seems opportune.

There are roads along the Kuma banks and some rail tracks. Their position (height) on the land surface in relation to the expected water levels during the passage of a design flood has been summarized in a clear longitudinal profile, but again based on a 1999 survey. Since then, in the Kumamoto prefecture also the North-South motorway and the bullet train have developed, may be that has changed the urgency for adaptation works of the older infrastructure along the river. Perhaps an update of the 1999 survey is required therefore.

Q A potential severe danger!

One of the last pages of the document file as provided to the members of the Knowledge Assembly, shows a cross section from South to North of the river bed and adjacent urbanized land on both sides of the levees at Yatsuhiro. In that cross section, the highest expected flood levels in the Kuma are also shown, as well as the situation of the Hagiwara levee.

This illustration is astonishing: it shows similarities with well known potential dangerous situations elsewhere on the globe, such as the low flood prone polder land behind the river dikes (levees) in the Netherlands, and the New Orleans situation along the Lower Mississippi. A dike burst in such areas will cause terrible damage and devastation, so the quality of the main flood protection dike must be absolutely guaranteed. That urges regular inspection and maintenance of the levee, and a clear description of responsibilities and accountability. More in particular, if on the crest of the dike is also a public road with many additional facilities for

the daily safety and regulation of traffic, and/or if directly at the inner side (or still on the lower part of the inner slope) of the levee other infrastructure is located (such as a rail track). In such cases some major questions should be answered very clearly: who owns what, who maintains and pays for what, who is supervising, how is the enforcement arranged, and who is accountable for what?
And in addition to this, non-structural measures should be worked out, e.g. early warning systems, evacuation schemes, calamity control, etc. Also the composition of risk maps is recommended, the more so because in particular on this issue Japan is a forerunner when compared to the situation in other countries in the world. It is strongly recommended to discuss these issues with all official parties involved at all levels, e.g. the government, the prefecture and the municipality.

8 An alternative solution for flood control measures, focusing on the safety of Hitoyoshi down-town; theory, idealism or realism?

In paragraph 4, reference is made to five options when working on the flood control safety at Hitoyoshi down-town. Common engineering approaches are respectively 1) deepening and 2) widening of the channel, 3) a combination of both, and 4) manipulating the run-off of the discharge. A theoretical last alternative, 5) a combination of widening-deepening-reservoirs, has not yet been stipulated in this report; it is done hereafter.

A theoretical compromise solution could consist of the following elements.
The main channel at Hitoyoshi measuring point will be widened and deepened, whereby the existing rock island opposite the down town area will be removed. In addition the span and the height of some critical bridges at Hitoyoshi will be adapted. Furthermore, because the discharge capacity at Hitoyoshi in the channel will be increased, the reservoir capacity at the planned Kawabe dam can be reduced considerable. However, there will be built still a dam at the planned site in the Kawabe although with a much lower crest, so that the created reservoir will become much smaller as planned till now (it is recommended to build a lower dam, but with still the same dimensions of foundations etc. as designed for a 107 m high dam, just to remain flexible for the far future, in case practice will show (later on) that the reservoir capacity of the dam must still increase). The remaining reservoir capacity as still needed will be achieved with the building of some additional but much smaller dams in the Kuma basin upstream Hitoyoshi, in addition to the creation of the proposed nine basins directly parallel along the Kuma upstream the confluence with the Kawabe. A technically suitable location for the other still needed smaller dams (masonry/ earthen) can perhaps be found in the main valleys of the headwaters of the Kawabe upstream Itsuki village or in the valleys of other tributaries of the Kuma. ***Note: additional small dams should of course only be located in valleys of tributaries of the Kuma, where during typhoon precipitation a substantial contribution is generated to the design discharge, upstream Hitoyoshi.***
Doing so, the required capacity of about 110 million m3 may become distributed over more elements, possibly roughly as follows:

- *increased wet profile Hitoyoshi channel 200 m2, taking in 12 hrs about ……………..25 to 30 million m3;*
- *maximum 50 m high crest Kawabe dam, storing about another……………………… 25 to 35 million m3;*
- *9 reservoirs along the Kuma as proposed by (dam) opponents, storing about …………15 million m3;*
- *2 small dams in headwater valleys Kawabe river, storing together about ……………15 to 20 million m3(?);*
- *a number of small earthen dams in small tributaries of the Kuma, upstream Hitoyoshi,*
  taking all together the remaining ……….10 to 15 million m3.

Taking all these estimations/assumptions together leads to ……… 90 to 115 million m3.

This alternative must be considered first of all as a theoretical option, however it can also be considered as a complicated compromise. As such it may be an interesting (but expensive!) option for a political decision. It must be stressed that if ever a decision would be taken, opting for this alternative, the actual flood-control-managing aspect of the various works as being crucial parts of the alternative, will be and will remain complicated. In that respect the alternative must be considered for the time being as a theoretical option. Thereby, it will be

costly as well, while also negative environmental impact will be/remain involved which cannot be compensated entirely with mitigation measures
If this alternative compromise solution is considered as being interesting enough for further planning, all elements must be elaborated after expensive additional field survey at all relevant locations. No doubt, that will take some time. Then the mitigation measures must be worked out, for compensating environmental and socio-economic impact. Finally the financial consequences must be determined and public disclosure must start (again).

9 General conclusions.

In this paragraph, the essence of the blue text blocks, as marked in the previous paragraphs, is taken together. It leads to the following general conclusions.

- The fortunately still unspoiled nature of the Kuma, flowing in a mountainous and beautiful landscape, has created a visible balance between economy and ecology, prosperity and welfare. The population in the river basin, now and in the past, earns most credit for this.
- A safety standard against flood protection of (only) once in eighty years is low.
- The determined design discharges of 7,000 m3/s at Hitoyoshi measuring point (1:80 years flood) and 9,900 m3/s at Yokoishi measuring point (1:100 years flood) are considered to be correct and give no reason for serious disputes.
- The duration of the peak design flow at Hitoyoshi is 12 hours, indeed. It is roughly estimated that in that case the average current velocity in the channel is about 4 m/s.
- It certainly cannot be predicted what precisely the actual discharge capacity of the main channel at Hitoyoshi during the passage of a design discharge will be. Also freeboard under the crest of a flood protection system cannot be guaranteed. However, having seen and heard about the situation, the assumption that the major channel at Hitoyoshi measuring point can only take 4,000 m3/s during the passage of the basic flood discharge, is supported. The remaining 3,000 m3/s must find its way over the banks and adjacent urbanized land.
- The most striking flood control problem in the Kuma basin is found at Hitoyoshi city. All other flood related problems in the basin are (technically) minor when compared to this. Many people are aware of this.
- The determining technical flood problem deals with finding a solution for the temporary storing of about 110 million m3 water somewhere upstream Hitoyosi, as generated during a tsuyu typhoon storm lasting 12 hours with heavy precipitation in the Kuma basin.
- Finding and creating substantial additional discharge capacity in the main channel at Hitoyoshi will urge the blasting and excavation of many rocky outcrops along the banks and on the bottom; this will have environmental impact. In addition, it will generate a claim from the tourist sector, although such a claim is utmost minor when compared to the real problems (technically, environmentally, financially).
- From an engineering point of view there are three main options in case a substantial upgrading of the discharge capacity of the main channel at Hitoyoshi is needed: deepening, widening and discharge manipulation. In addition there are two more, being combinations of the main three options.
- From an engineering, hydraulic/hydrology and geological point of view the planned site for building a single (Kawabe) concrete dam is chosen at the one and only right location. If there appear to be still other options for building in addition smaller dams somewhere at strategic places in the catchment (see paragraph 9), the height of the crest of the planned Kawabe dam can be designed substantially lower.

- The suggested proposal as done by dam-opponents in the Hitoyoshi plain, to make 9 areas of fertile agriculture land suitable as retention basins, is not realistic. The actual storage volume there in terms of m3 is most probably far minor to the suggested values. In addition encircling bunds/levees are needed to be constructed on private land and maintained regularly in the crop season.
- In case climate change will cause higher peak discharges over longer periods in the future, any planned flood control measure as planned in the Kuma basin must remain flexible enough to anticipate on that consequence of global warning. The planned Kawabe dam is sustainable in that respect indeed.
- At the Hagiwara site, overtopping of the levee is no problem at all, the works are only needed because of utmost dangerous stability problems. Having heard the arguments of the opposing groups, unfortunately there is no people awareness on this major threat.
- Gravel dumping in the channel can be considered as some kind of mitigation measure.
- At the major land fill sites along the Kuma, it is recommended to watch effects such as subsidence and compaction, while a proper drainage during the wet season(s) remains crucial.
- It is recommended to look at least for construction types of revetments that are well known as environmental friendly and sustainable under the circumstances. Ample literature exists on the subject.
- Levees are artificial (man-made) constructions. Their construction may decline in due time, reason why regular inspection and maintenance is (and remains) urgent. Degradation is caused by subsidence, compaction and just damage, while also at transitions often failures occur and repair is needed. Therefore at least regular planned checks are needed.
- There is another aspect to be watched carefully due to the mechanism of fine fractions being washed out during the passage of floods. That has to do with the stability at the tow, under water, of extensive lining systems (revetments) along land fills and housing thereon in the middle reach. In case there is no proper filter (geo-textile) in the construction of the revetments, it may be possible that the tow will finally become unstable and the above laying revetment will collapse in due time.
- The backwater impact as occurring at the three dam sites in the mountainous reach (Setoishi, Arase, Yohai-zeki) during the passage of peak discharges, must be carefully analysed, in particular just upstream of those sites already mitigation measures have been carried out.
- Degradation of rock material, when exposed to air, is a crucial issue, developments must be followed and watched carefully. In case instability problems threaten bridges (pillars and abutments) and revetments, direct corrective measure are recommended. Further coordinated research on this matter makes sense.
- The influx of sediment in the reservoir behind the planned Kawabe dam will increase due to increasing mud slides on the steep slopes of the valley, so there may be needed some adaptation of the planned (sediment) flush capacity from the reservoir to the downstream valley, on the longer term.
- It is recommended to elaborate on mitigation measures, compensating environmental impact, in a special (accessible for outsiders) report. It should be done in a way that protests etc. as heard during the last years are reflected in the measures to be planned and finally to be taken and implemented.
- Tourism at Itsuku village is served with stable reservoir levels in the tourist season. This is an important socio-economic issue for the community!
- In addition, the planned conservation measures to be taken for tourism and natural landscape should be taken up in such a report as well; an issue in this respect is stabilizing the minimum flow during the dry season; this may extend the length of the tourist season.

- The documents as provided show research data on the matter of bridges etc. crossing the Kuma, as of 1999. It is recommended to make an updated inventory on the most critical situations. Also an inventory should be made of the costs needed to adapt at some locations the design of a bridge. A renovation plan on the medium and long terms seems opportune.
- In cases of the existence of integrated infrastructure (levee cum public road cum rail track) some major questions should be answered very clearly: who owns what, who maintains and pays for what, who is supervising, how is the enforcement arranged, who is accountable for what, etc.?
- In addition to the previous point, non-structural measures should be worked out, e.g. early warning systems, evacuation schemes, calamity control, etc., where opportune.
- The composition of risk maps is recommended, the more so because in particular on this issue Japan is a forerunner when compared to the situation in other countries in the world.
- It is strongly recommended to discuss the above mentioned three issues (integrated infrastructure, non-structural measures, risk maps) with all official parties involved on all levels, e.g. the government, the prefecture and the municipality.
- In paragraph 8, a theoretical alternative is stipulated. If this compromise solution is considered as being interesting enough for further planning, all elements must be elaborated after expensive additional field survey at relevant locations. No doubt, that will take some time. Then the mitigation measures must be worked out, for compensating environmental and socio-economic impact. Finally the financial consequences must be determined, before public disclosure can start (again).

10 Main conclusions.

With the above in mind, the main conclusions are as follows. There are two extreme options, a final solution may be some compromise in between. The two extreme options are:

a) Either the Japanese society gives the Hitoyoshi community the credit it earns, by accepting that the city there is served indeed with reasonable safety against a 1:80 year design flood at least, to be achieved by building the Kawabe dam as originally planned; in that case the building of the structure must be phased carefully.

b) Or the Japanese society is not willing to offer the Hitoyoshi community a safe and livable place, by not accepting building the planned dam, with the consequence that the down-town centre may finally become 'bulldozered' and the riverbed over there will become substantially deepened and widened in a way that no doubt nature will become destroyed on an unprecedented scale.

The various elements of the two suggested compromise solutions as mentioned under ref. d) in paragraph 4, and in paragraph 8, must all still be elaborated and optimized; up till now research in this respect has not been done. Anyway, there are more combinations possible, the optimum solution in terms of investments should be first determined, if opportune.
But whatever combination is finally opted for, at least still a dam (but) with a lower crest as originally designed at the planned site in the Kawabe, remains needed.

A political decision at Governor's level is significant,
for ending the dispute over whether the Kawabe dam
should be accepted or not.

11 Epilogue. 'These are the days'.

The planned Kawabe dam has generated a national dispute, but outside Japan the project is rather unknown. One of the reasons is that the information on the project is rather difficult to be found on the internet, the more so because professional publications on the project are mainly restricted to Japanese language, so not really accessible for foreigners.

As such, when implemented, the dam as a physical structure will be a type of infrastructure facility as known all over the world and (still) common in the so called wet civil engineering sub-sector. In addition, in civil engineering there are also physical structures representing facilities in the so called dry sub-sector. Well known examples in Japan are the major facilities for motorways and bullet trains, all across the country.
In recent times, on the Kyushi island in Southern Japan, both a first class motorway has been built while preparations for a bullet train are ongoing. Taking note of the massive concrete constructions as designed and implemented for these dry-infrastructure facilities, no doubt they must have severe environmental impact. When the design of the planned Kawabe dam is compared with those two dry infrastructure projects in the Kumamoto Prefecture, in particular in terms of dimensions and types of works and their environmental impact (massive drilled parallel tunnels, high concrete pillars in vulnerable remote and curving steep valleys, CO_2 exhaust, slope protection with large scale constructions, etc.), no doubt the Kawabe dam will be in terms of physical scale and environmental impact the minor facility of the three.

During my short stay in Japan, July 10 -15, I have wondered how intensive the public debate must have been in Kumamoto Prefecture in recent years on the new motorway and bullet train. Can it be compared with the discussions and dispute on the Kawabe dam? Although the plans for the Kawabe dam are in scale, and perhaps also impact, minor to the two dry infrastructure projects, the discussions and continuing disputes on the planned dam dominate in Kumamoto Prefecture (and Japan) when compared to the other two mega projects. One may wonder why. It is remarkable why the safety of Hitoyoshi community is not considered as a major issue by opponent groups in this respect, the more so because mitigation measures for compensating environmental impact due to the planned Kawabe dam are numerous.

In this respect, I would like to end with a well known paradox as experienced all over the world. Taking note of that paradox leads to self-reflection at least, I assume.
In the industrialized world, including Japan, major properties of individuals such as houses are insured against robbery and fire. It is some kind of personal safety, which is required by most people. Nobody will raise objections when paying the annual premium for that.
In the same industrial world, so also in Japan, people want to be safeguarded against nature disasters, such as floods. An effective way for doing so is the construction of dams in combination with compensating measures, e.g. for environmental impact. However, taken note of intensive disputes on these matters, a society is not always willing taking the consequences and pay for required security.
Now, the paradox is that the chance that an individual will experience in his/her lifetime that his/her house will be robbed/burnt down (for which annually an insurance premium is paid without any objection), is in fact much (again: MUCH) smaller than the chance that the same individual will experience in his/her lifetime that a design flood (1:80 yr) will pass nearby his/her place (for which nobody wants to pay his/her share for financing a dam).

August 1st, 2008,
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