# Sabo Vignette
# Adaptive river sediment management in Upper Tenryu Reach

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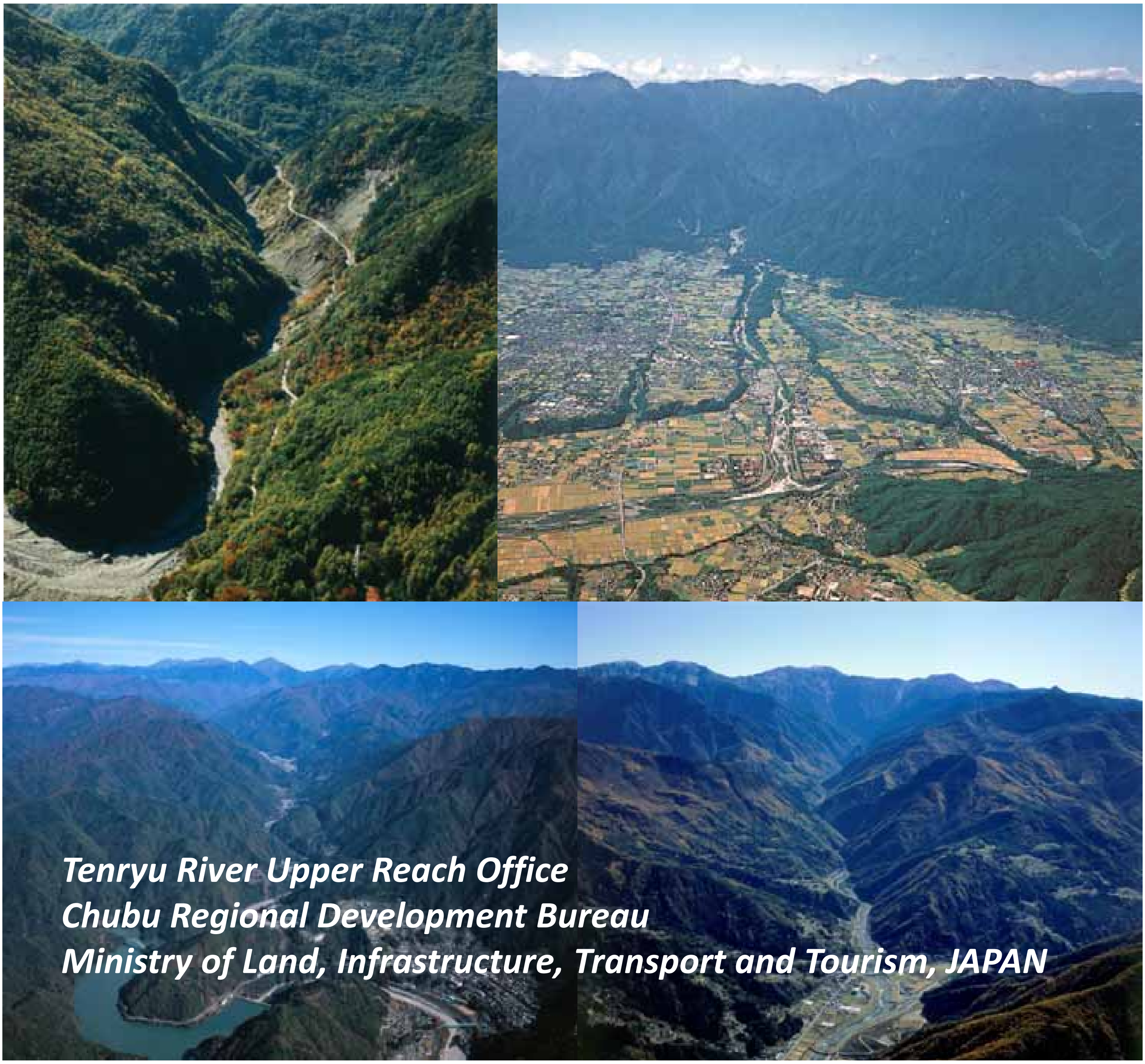

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*Note: The name of the river has appeared in various documents since as early as 8th century. It has shifted from Ara-Tama, through Hirose, to present Tenryu. Each has an implication of its own. Ara is a name of wild coastal ruling tribe whereas Tama is a title of a princess in upper reach. A metaphor of a marital bondage between two different tribal groups. Hirose is simpler, in that Hiro is an adjective wide while Se is shallow water. Chinese letters of Tenryu are made of two parts: Ten and Ryu. Ten is heaven (caelum in Latin, celestial/heavenly as adjective). Ryu is a flying entity, generally of good intention to proclaim prophetic messages. Therefore, cherubim river would be the literal translation in English. Folklore used Ookawa, or Kawa, each of which merely indicates big river or river itself respectively. The upper reach is also called under the name of Inadani, which is Ina valley, consisting of a basin.

I. Scope

Sabo work is a form of mass wasting management. It has also been transcribed as erosion and sediment control/management, but the Japanese noun "dosha" is more precisely mass in general than sediment, which may invoke a sense of material deposited in channels. Destabilization initiates mass movement. It sustains damages acutely and undesirable impacts latently upon the society in basin-wide scale, depending upon the timing and locality. The mass focused upon is chiefly the one destabilized by natural factors such as slope surface water and ground water produced by precipitation. It could include those of man-made nature in case the perpetrators are not readily identifiable. The former condition puts out of sabo work the case of groundwater infiltration from mismanaged irrigation and aqueducts, for example. The latter, abandoned gravel wastes after development projects, land utilization, and mis- and/or de-planted forest land. On the contrary, volcanic surface mass phenomena when their source is rainfed are worthy to be listed as an object, at least for monitoring and observation, even though they have long been categorized as caused solely by hot bottom water springing-up from beneath. Also subject to an examination for emergency work taken over by sabo work, for a moment, is that which may lead to irrevocable downstream impacts upon third parties without fault, when the identification of wrong-doers, proper cost charges, or mitigation efforts by other legal measures are not within reach, invoked diversely in forms of mining and manufacturing, agriculture, forestry, development project, and environmental project (waste/deposit management, factory demolition and site clearing). Sabo work is taken to achieve a public benefit of non-identified third parties in downstream areas by proactively lessening mass wasting, a hazard, whose timing of occurrence may or may not be known precisely beforehand. National cost share for sabo work, often in the form of subsidy rate, is set to be higher than public works in general both in the face and in the net value, after retroactive re-compensation of expenses/debts, in order to possibly lower local financial burden. Therein lies the significance of identification of culprits and beneficiaries, if there are. Varieties of large amount of materials are in circulation on Japanese archipelago through trades. The materials, after those exported or exhausted to the air or outlet to the ocean subtracted, are left accumulated on the land as mass wastes year after year. The net sum is larger essentially by an order of magnitude than the mass of soil and gravel washed out from the archipelago naturally (e.g., Ministry of Environmenta, 2015). Thus, its importance as an issue both to the society and to the land conservation. Manmade goods and their wastes are definitely anthropogenic in the character that they are duly to be dealt in accordance with the polluter pay principle by a traceability conducted by an institution of manifesto. Mass wastes are, therefore, not an intrinsic target of sabo work, which is a kind of public works with benevolent national share.

At local level, the upper Tenryu reach is chronically uplifted by active geologic plate motion both by Akaishi mountains in the eastern side (Japanese southern Alps) and by Kiso mountains in the western side (Japanese central Alps) and often exposed to relatively large amount of precipitation, which result in destabilization of hillside and mass wasting, the focus of sabo work in this reach. Mass wasting troubles in the tributary ravines are readily comprehensible. Those in the main channel of Tenryu river are not so clear that they may need some notes as follows:

a. The configuration of the river is disproportionally long in north-south orientation by the constraint of high mountains at both sides (as shown in Figure 1).

b. The amount of precipitation in the northern upstream source basin at the western skirt of Mt. Yatsugatake is relatively inadequate in proportion to the size and the amount of river sediment supplied from mountain ranges.

c. There are non-negligible time lags between flood discharges in the main channel and sediment discharges supplied chiefly from tributaries, partly for the cause of lake Suwa, a geologic rift lake, in the northern edge and of reservoirs in principal tributaries.

d. Channel-wise longitudinal flows are hindered by bottlenecks formed by various uplift motions including many active faults and by reservoir dams in the main channel.

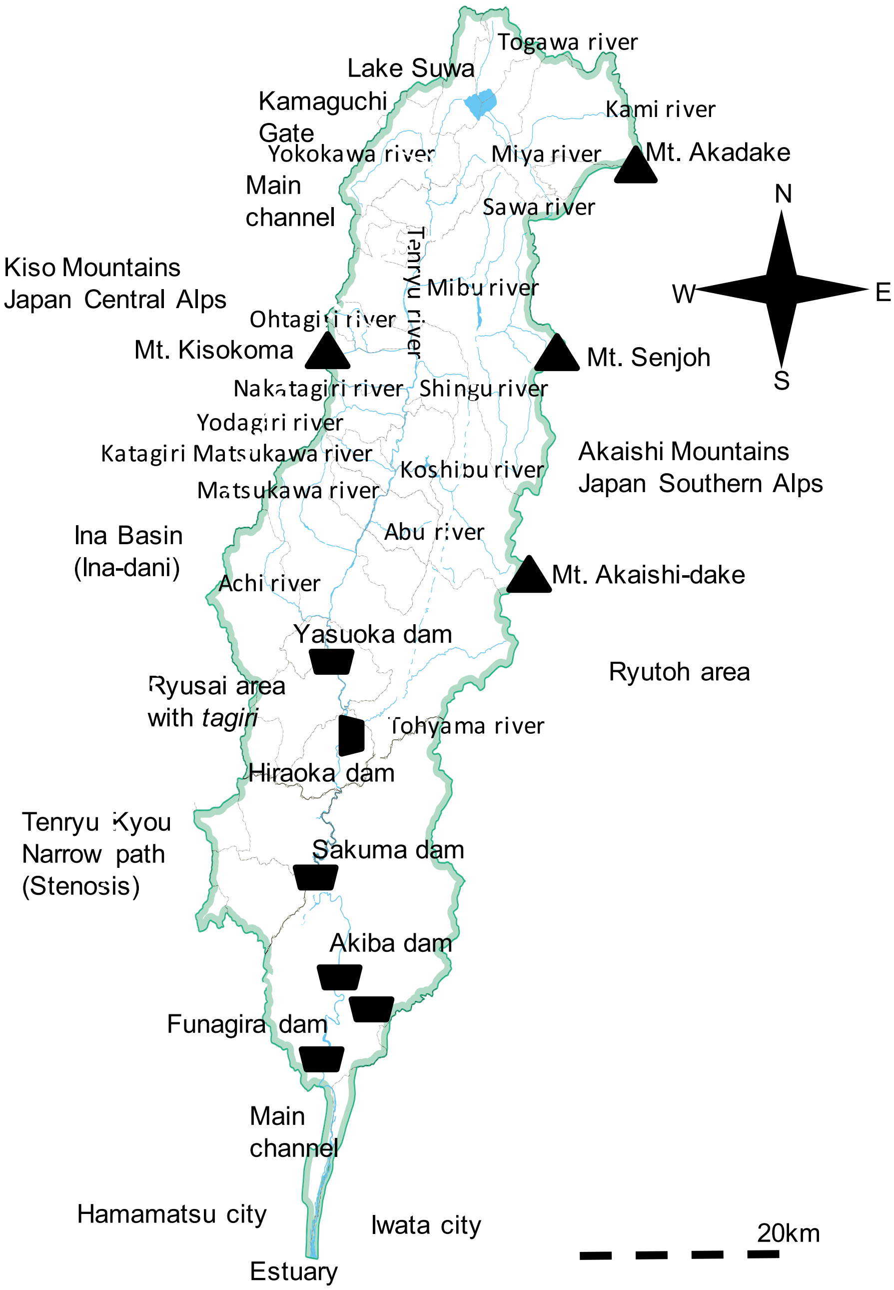


**Figure 1 Overview of Tenryu River**

Trends in other industries are unlikely to induce additional impacts on the mass and sediment subject to sabo work, due to prolonged economic standstill after a period of economic growth, but for a few exceptions. Note, however, that they may demand an engagement of sabo work up to identifiability and chargeability against the liable, together with applicability of other legal means. For instance, mining and manufacturing have not been a major sector in the area. Agriculture and forestry heed attention for the impact of poorly maintained drainage networks and for degradation and/or deforestation, exacerbated by prolonged sectorial downturn. Notably, fast-growing wildlife communities such as Japanese deer have unintended and unwanted impacts on soil erosion and surface failures (Picture 1). Waste disposal from development project of highway and Maglev bullet train, together with the mitigation of their adversarial impacts on the third parties, is on principle administratively guided and coordinated so as to hold each enterprise accountable, lest one may opt for sabo work. Environmental work of incinerator and landfill site, with moderate scale, is presently either under construction or under preparation, on the principle of local circulation as "waste locally and be handled locally," as the time has passed sufficiently since prior projects. However, exploration and planning of major scales are not in the sight, due to poor road transportation and inadequate potential landfill site, gently undulated hills with a quasi-equal range of summit, for example. Business failure of any sorts of industries is to be paid careful attention because of its potential to leave unattended abandon sites without sufficient clearance, a cause of adversarial mass wasting impacts on the basin, whose responsibility is oftentimes not trackable.

Picture1 Devastation by Japanese deer
(Left: trampled path, Right: grazing movement)

Scoping of mass and sediment as an object of sabo work as above-mentioned does neither determine the engineering measure for resolving problems, nor, at the least, alleviating the impacts thereof. It is normally advanced to make an informed selection of a few basic quantifiable properties of related phenomena after general but careful observation. Selection of basic properties of practically measurable sorts enables us to examine its own behavior, and the physical and/or statistical relationship with other properties when there are some that leads to a construction of quantifiable mathematical models, which oftentimes are a preposition both of concise explanation to other interested parties and of budgetary resource allocation in concurrence with other public works.

Sabo work has long made use of short to middle term changes of mountain and riverine longitudinal and lateral land configuration, especially traces and leftovers from mass wasting left on slopes and in ravines after salient major washout by disasters, as basic properties. However, bedload discharges flowing downstream during floods and those less than the size of sand grain by normal flows after floods have not been attended adequately for measurement so far, despite their large share in mass and sediment movement.

Research and development efforts have been made in upper Tenryu reach, preceding those of other offices nationwide. Therefore, this paper introduces several items put recently into watch and observation lists, with the measurement methods. Keeping observational records and analyzing them to the extent possible enable us to hold a long-range view and are useful to eschew myopic budget wasting works of removing mass and sediment, which would have been flowed away naturally by river at no cost.

There follows introduction of more cost-effective engineering methods in project fields, and of information dissemination on a daily basis and in emergency situation. Dissemination and public outreach are basic conditions of promoting wise land use and conservation efforts on the part of other parties and local residents. They are also essential to adjust proper financial allotment subject to the level of local cooperation, and are undertaken in collaboration with Nagano prefecture and each local municipality that have basic responsibility for local sabo work, namely mass and sediment administration.

## II. Comprehension of phenomena

Field practice has hinged upon water stages for river basin management in this country. The method makes an estimation of flood discharges based on statistical relationship between flood stages and discharges obtained at the time of past floods, regardless of the fact that they are oftentimes less than major scales. Rapidity of rivers with a sizable concentration of sediment changes configuration and river bed level up to 5 to 10 meters even during a short duration of a flash flood. Chronic and long-term scouring transforms the configuration beyond expectation as well. Water level has its limitation. It does not consist a complete set of basic properties. Precipitation, a supplemental property, is taken in general to make a model-based estimation of flood discharges in order to provide a practical foundation for facility planning and flood forecast. Each method has its own advantages and disadvantages. Dependence upon models for estimation is often criticized for the following reasons:

a. Deficiency of precipitation records in mountain ranges in terms of precision and of stations available.

b. Flood fighting is guided through water levels whereas flood facility planning is through flood discharges. The dissimilar conjuncture of basic properties could lead to unwanted miscomprehension at field level.

c. Models are hardly able to take into account prospective changes of discharge parameters engendered by land use and development in river basins.

d. Installation of river facilities, together with land use within river channels, including tree growth out of the range of normal water way, shifts the relationship between water stages and flood discharges considerably. The shift makes it difficult to improve the reliability of facility planning through comparison with historical flood records.

e. Present hydraulic and hydrological observational system in upper Tenryu reach is shown in Figure 2.

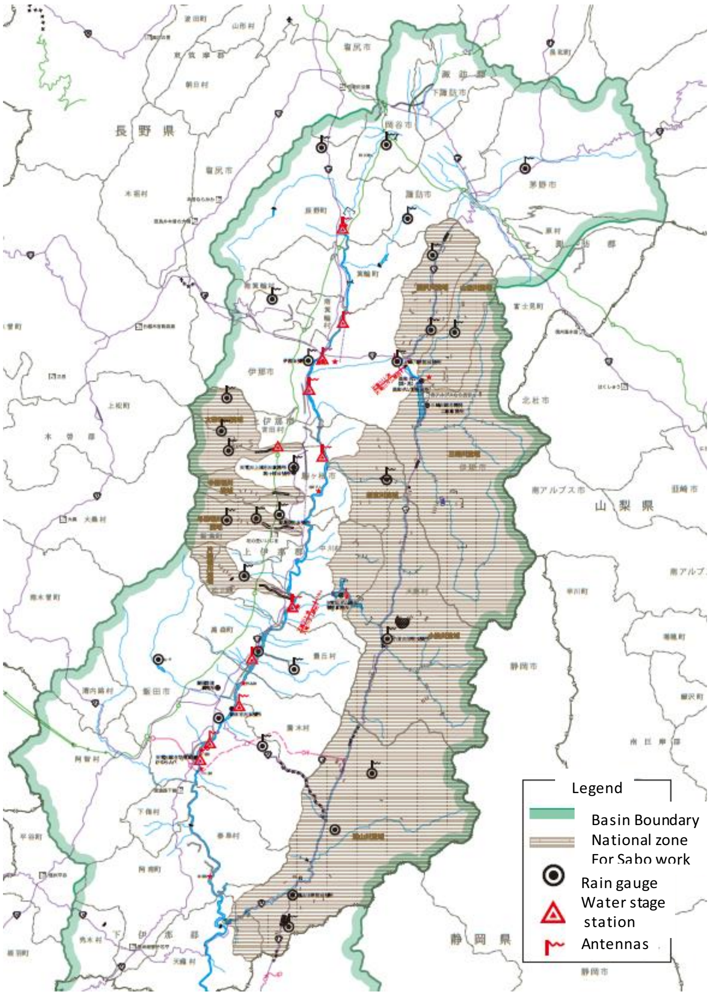


**Figure 2 Current Observation Stations**

Class A river is administered by the Ministry of land, infrastructure, transport, and tourism (MLIT) under national jurisdiction. River and water use in the country have been established firstly for agricultural irrigation and secondly for hydropower in modern era under the auspecies of different authorities, however. As a result, laws and regulations related to rivers are legislated and enforced so as to give priority to the preceding water rights, entitlement, and its holders. There is a tension by nature between water right holders and legal authorities who accord and periodically update the nominal, nonetheless legally-binding, permission. The tension would be an explanation why hydraulic and hydrological observational data are not fully shared on-line in this digital ICT age. The most major hydropower water right holder in upper Tenryu reach, Chubu Electric Power Corporation, has the majority of data. Attempts are made for on-line sharing with the purpose for more effective real time flood management. Figure 3 depicts the categories and locations of observation shared finally from Chubu Electric Power Corporation to MLIT. The gap of observational data is considerably filled in the southern part of Ina valley.

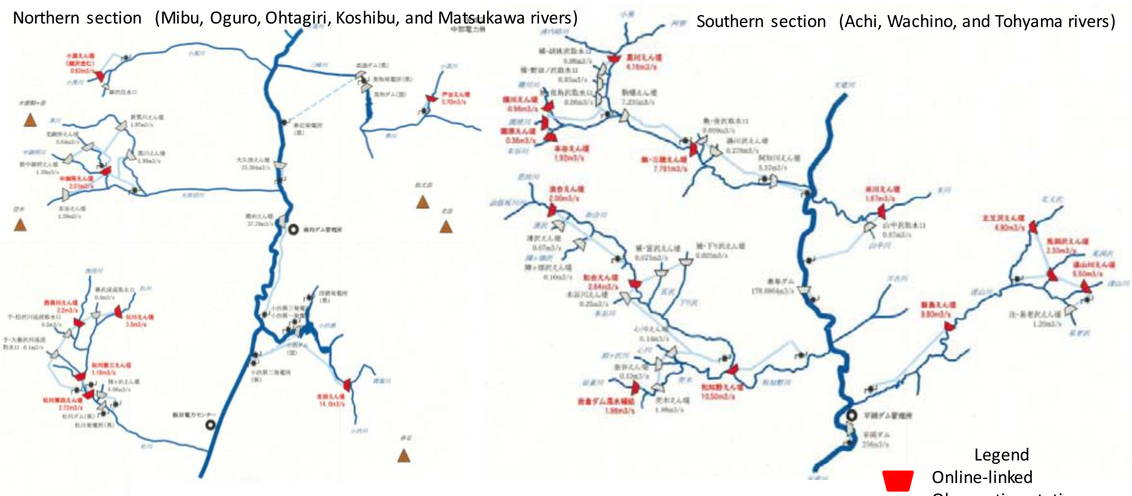


**Figure 3 Observation data to be shared by Chubu Electric Power Co.**

Rapid as Japanese rivers are, they have high river discharge coefficients, a ratio of planned flood discharge to that of normal, than continental rivers whose flows are gentle and stage rises are seasonally forecastable mostly. They present many challenges to the observation of water stages and flood discharges as following:

a. Discharges and changing modality and dynamism including secondary flows make it hard for gauging floats to respond in a timely manner.

b. River bed transformation sometimes blocks stable river water intakes.

c. Changes of depth and form resistance by river bed transformation during floods leads to an unstable relationship between water stages and flood discharges in turn.

d. Observational records are oftentimes not available because of the loss of water gauging functions. They lose their functions by damages or by complete destruction at the time of floods, of the magnitude of floods designated for facility planning.

e. Floods of rapid streams contain not only water of atmospheric origin but also sizable amounts of sediment, logs, and waste of various sorts frequently, whose effects and contribution to flood discharges are not straightforwardly estimable.

Improvement of measurement methods currently depending on gauging floats, a direct contact method, to some kind of non-contact one can be a practical solution for the above-mentioned challenges. The issues entangling discharge estimation are to be resolved once flood discharges themselves are adopted to be a principal object of observation and estimation, instead of water stages. On the other hand, visionary images at principal points in main channels have been widely captured in Japanese rivers via high resolution digital closed-circuit cameras to meet various river management needs. So far, they are essentially for real time watching. Put otherwise, they are not fully utilized in that they are discarded mechanically after set period, without thorough analysis on time or digital compression storage for future study. Images data are in that sense unused observational resources. The fact of the matter is that flood discharge estimation from images has been under development for a long time because of its obvious advantages, over direct contact gauges, of robust continuity of measurement even during major floods. Time differential vectors of identified objects on flow surfaces between two successive snap-shot moments have been a central research topic up to this date. Image streams demand a good size of conduits as well as major computing power, resulting in impractical unit installation cost. On the other hand, their precision remains an unsatisfactory level because of nocturnal image quality degradation and scatters/reflections either by disturbing objects such as leaves and twigs, or by rain shower right in front of cameras. Ravines in upper Tenryu reach are rapid, but their lateral widths are not wide. There are installed a number of facility and sabo structures optimal for imagery targets both in the main channel and branches. An attempt is made to computationally mimic a rule-of-thumb analog guesswork by river engineering practitioners at field sites. The method is simple and less cost intensive in that it makes estimation out of a few peculiarities within a window of instantaneous snap shot. A level of reliability, though not complete, is attainable even at night as it demands merely a limited number of peculiarities. Flood discharges well beyond past imagery records are also estimable by way of computational pre-learning of expected flood-time images of designated magnitude. A demonstration of the estimation from single snap shot images in

Koshibu branch basin is shown in Picture 2 for analyzed image and Figure 4 for time-wise line graph, respectively. The system is going to be extended basin wide so as to complement existing observation networks prescribed by general hydraulic observation standards.

**Picture 2 Peculiarities Extraction**
(Colored circles are extracted)

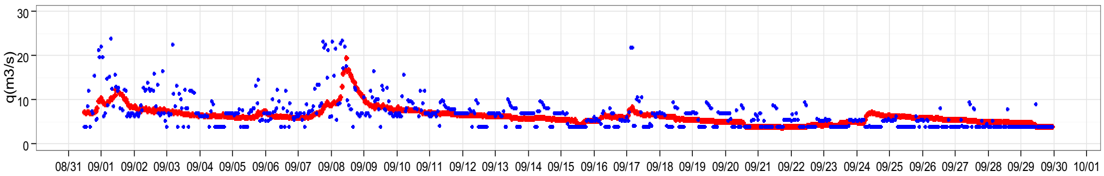


**Figure 4 Time series of discharges (September 2015)**
Legend ● Observed, ● Estimated

The subject of sabo work is mass and sediment. Both sabo work and flood mitigation work have precipitation and flow discharge as common agents. Precipitation comes into play as driving factor in the former and as major actor itself in the latter, while flow discharge works as a transporting agent. Instead of making an independent effort of research and development from scratch, therefore, sabo work and engineering have grafted onto similar measurement technology originally applied to general river engineering executed downstream in order to adjust it to mountain streams. However, much room of developmental effort solely in behalf of sabo work is left in the area of sediment discharge observation. It is because discrepancy of river flow regime makes bed load material a non-ignorable portion of river sediment in upstream. Bed load shifts, rolls, and salutes on steep ravine bed, while suspended load and wash load play almost all of the part in lower stream whose gradation is less than one hundredth. Small scale and experimental observation and estimation of sediment load, including bed load have been carried out at the right branch of upper Tenryu reach, Yodagiri river, since around year 2000, preceding other offices nationwide, achieving data accumulation and drawing various hands-on lessons (Figure 5). Full-scale application of monitoring and observation to capture total sediment loads is made in upper Koshibu river, the largest contributor of sediment to the main channel of Tenryu river from year 2015 (Figure 6). Data acquisition of longitudinal and dynamic observation is expected from another observation system in collaboration with Koshibu dam, located right downstream of sabo work areas, which is presently in final preparation stage to operate sand bypass tunnel.

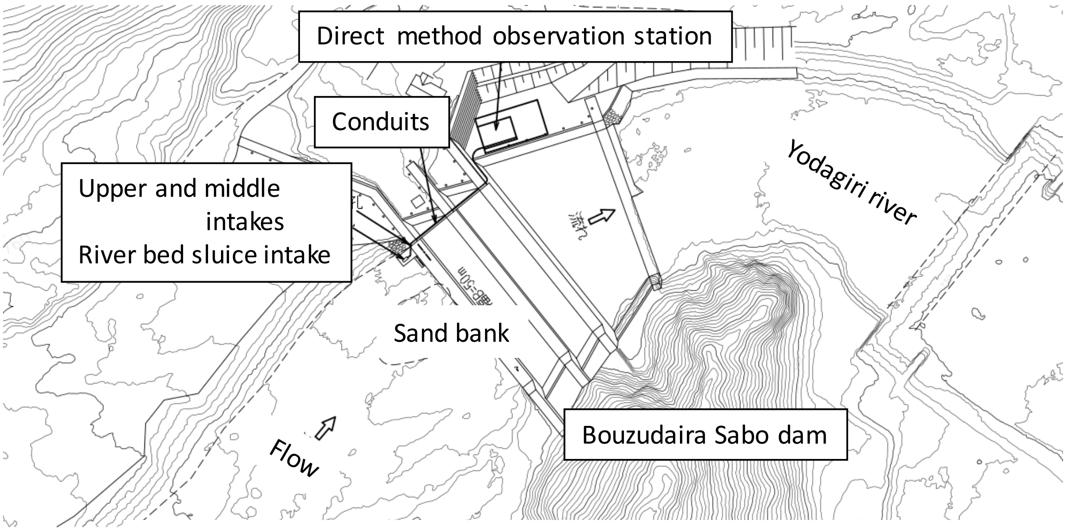


**Figure 5 Overview of Observation at Yodagiri river**

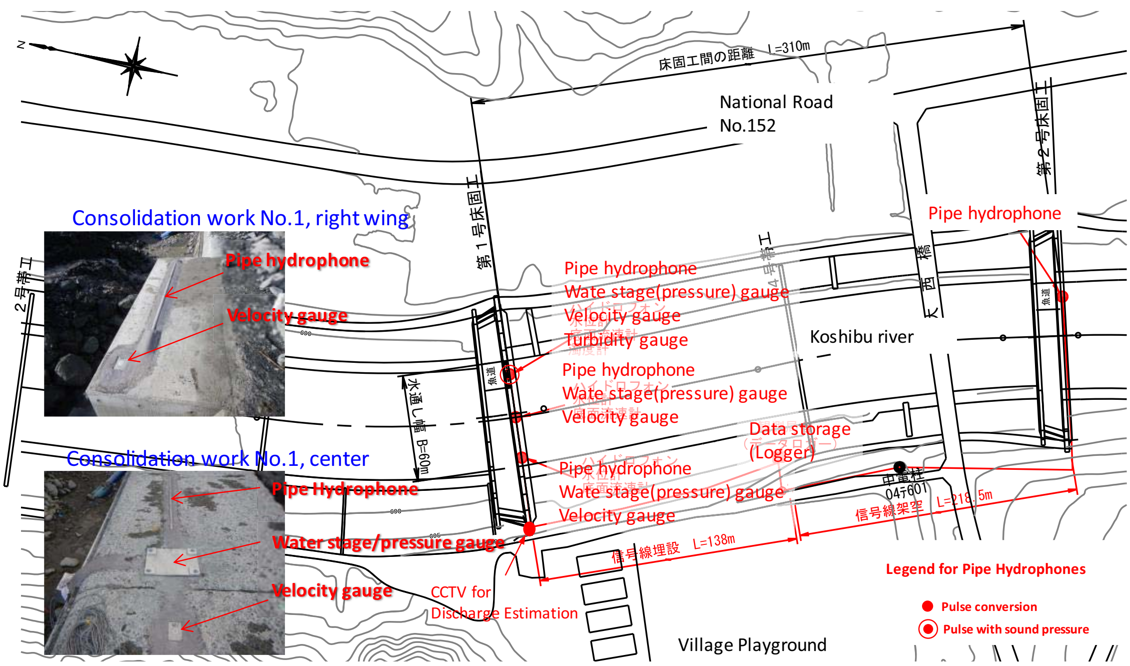


**Figure 6 Overview of Observation at Koshibu river**

Ground water flows and retards, caused essentially by precipitation infiltration, exercise a major influence upon destabilization of landforms in mountain stream areas. Monitoring and observation of ground water present more challenging than those of surface water in terms of applicable technology and budget constraints. Indeed, even preparatory survey has not been conducted fully, which is a precondition to find typical slopes appropriate for observation. Base river flows traced back to ground water from mountain bodies are perceivable in the form of inflow (increment of water depth) to major reservoirs. Monitoring of inflows to dam reservoirs is converted to an index for the purpose of watching regional potential of landslides triggered by excessive ground water, an effort of timely warning and evacuation (Figure 7). Levels and flow rates of ground water are monitored in legal landslide protection areas recognized for the pressing threat on residences and public facilities, although they are limited in locations and spots. Observation installation at Nyuya area in Oshika village and at Konota area in Minami Shinano, Iida city, are shown in Figure 8 and Figure 9.

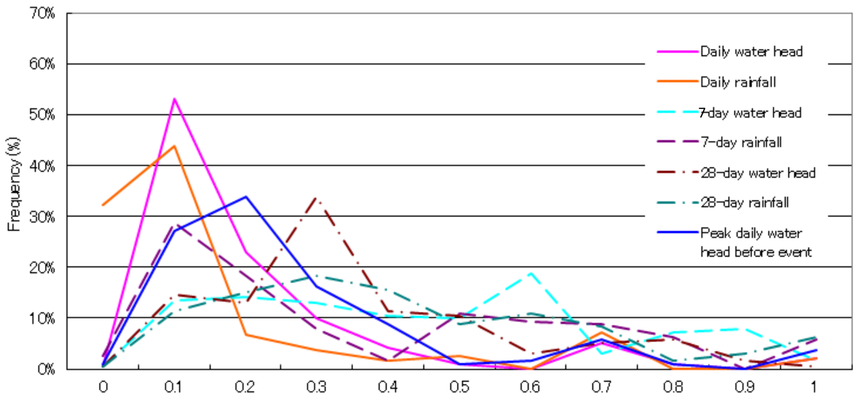


Figure 7 Frequency distribution of hydrological indexes related to landslides occurance
(All the ranges are set to 1.0)

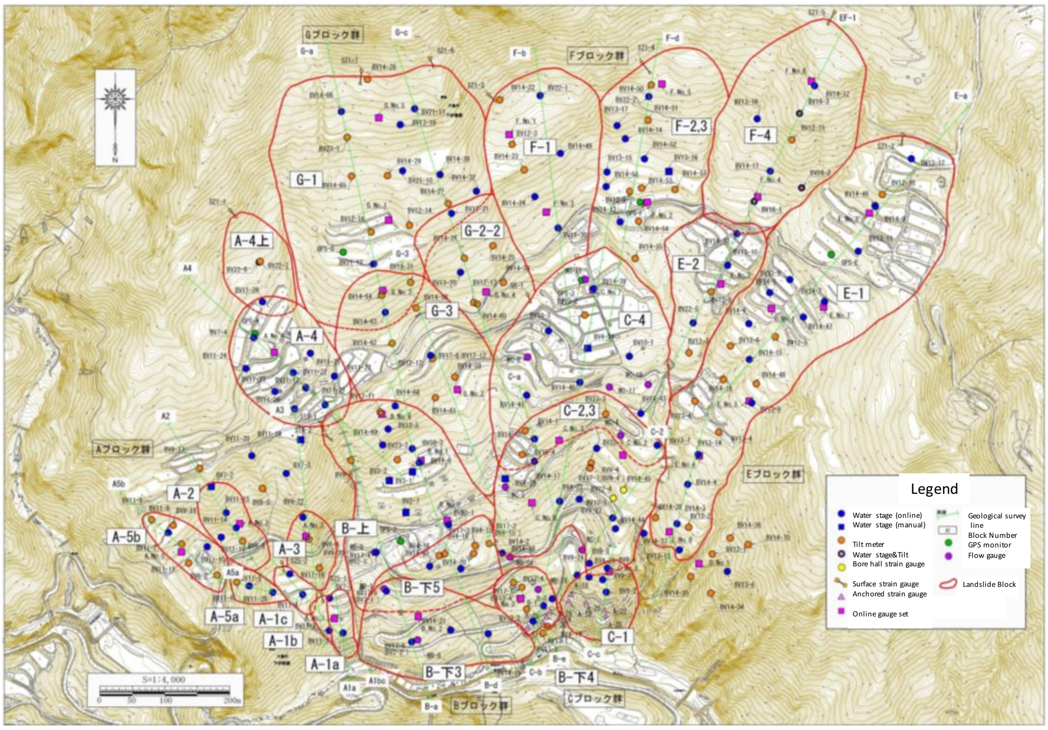


Figure 8 Observation gauges at Nyuya area, Ohshika village

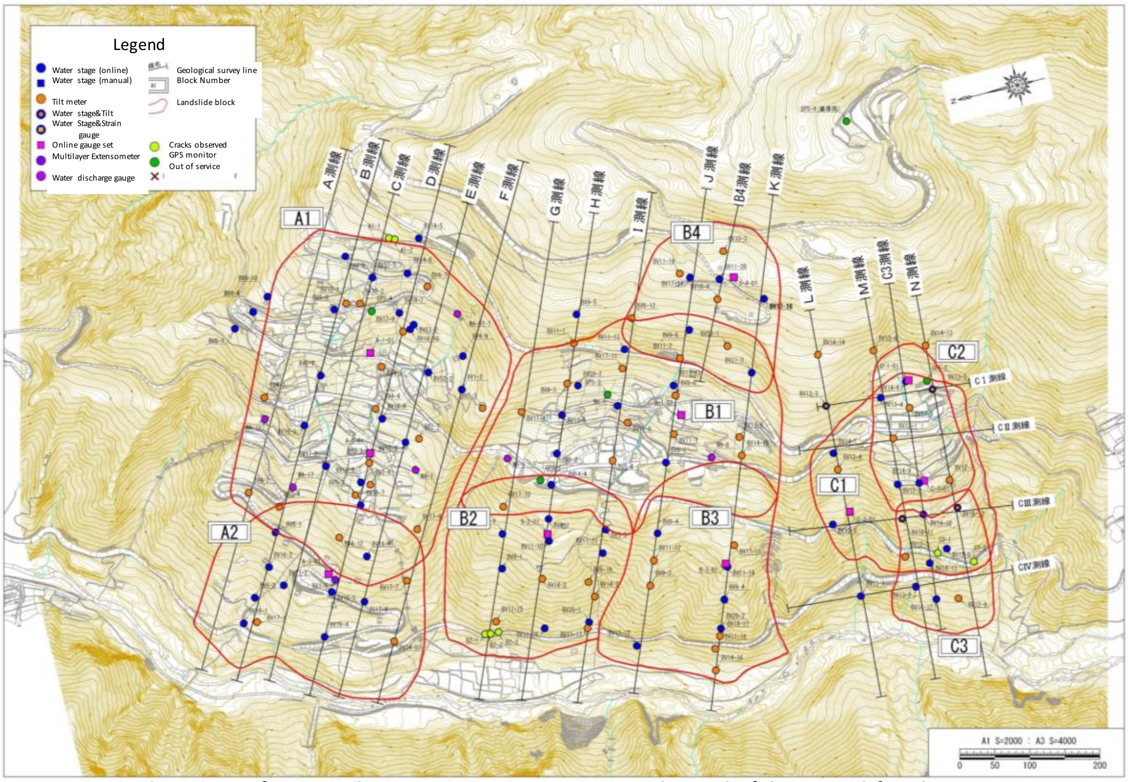


**Figure 9 Observation gauges at Konota, Minami Shinano, Iida city**

III. Direct actions on phenomena

Growing evolution of construction machinery brings mass exclusion of earth works in the practice of sabo work within reach as a way of engineering project. Expenses for removal and transportation per unit cubic meter range generally between four to five thousands yen within a hauling distance of 20 km. Mass and sediment exclusion sometimes goes beyond facility installation in the sense of narrow economic efficiency conjectured from direct expenses. Sediment and gravel derived from mountain streams are advantageous as material for their quality of roundness as well as soundness, and for lack of contamination. However, they are not always in a primary position, when seen from broader social costs with externalities, for the following reasons:

a. Regulatory restriction is strengthened upon gravel mining.

b. Market demand for river gravel and landfill material is low for long-term economic standstill.

c. Secondary and/or recycling use of sediment and gravel is not readily made in the field of public works and other major construction works in the face of lowering public works expenditure with major modal shift to maintenance and functional renovation of public facilities as opposed to new installation.

d. Sabo work itself produces a net surplus of sand and gravel as recycling use is pressed to the limit, resulting in less room for reception.

e. Landfill sites are seldom acquirable nor reclaimable in case fill-up is opted, as the rising trend of so-called green movement on the part of local residents.

Sediment and gravel obtained in place have been put in use in sabo work to the extent practical, by mixing them with cement-based additives. Recycling efforts of this kind have not seen perceptible advancement due to the necessity of adeptness and to the decrease of work sites. Sediment and gravel put out of work sites are hopefully made more effective use of for embankment loading and for river revetment at the foot of large-scale landslides, including potential deep-seated failures in upper Tenryu reach. They would be used effectively and economically to reinforce sabo dams when they are loaded and compacted next to the forefront downstream side, though technical standards are to be rewritten to make it permissible. In the meantime, mass and sediment in rivers, to the extent their adversarial impacts are minor, are to be excluded without budgetary public support. They would be removed chiefly by way of gravel mining, to which river administrators issue permission following engineering guidelines. Sediment and gravel removal of earth works is indispensable to keep, and to restore if possible, sand pocket capacity of sabo facilities for coming major sediment washout. It has also a high priority in wish lists of localities with a view of ecological riverside cleanup. The list has a wide spectrum from minor waterway cleanup to tree logging within rivers, which makes a tangible threatening obstacle in time of floods. Riverine tree logging and removal in mountain streams, where sabo work is put in place, are seen differently from those of lower rivers, where flood flow capacity has a prerogative. Mature deep-rooted plants play a needed and desired part to stabilize river bed against sediment washout in ravines. Therefore, tree plants are sometimes left untouched in river channels, waiting for future succession. Cares need to be taken lest sabo work may be confounded with river work. Practice of sediment exclusion is carried out under such condition as to stay away from facilities and to keep excavated slopes gentle for the safety and the maintenance of embankment and other surrounding slopes. Recent work site is presented in Picture 3.

**Picture 3 Sediment exclusion work on sand pocket**

The former era has seen installation of sabo facilities with the main purpose of protecting river bed and bank out of washout erosion through sand coverage, which is provided by naturally trapped sediment at their backs (sand trap and non-permeable type of sabo dam). Recently, however, more emphasis is put on the protective function for the downstream out of harms of debris flows and massive sediment washout. Such function requires natural restoration of sediment trap capacity, in combination with adequate sediment replenishment for downstream river bed, after temporarily capturing planned major sediment discharges (permeable type of sabo dam). The latter, permeable type, makes use of grain-size difference of river sediment, larger in times of major floods while smaller in minor. Permeable types have better efficiency when they act as designed. Those with detachable lateral closure screen bars are expected to perform best because of their superior restorability of sand trap capacity by natural minor floods, as lateral screen parts are temporarily taken out to open slit waterways for sediment outflows. Those with lateral screen have prerogative in the planning of functional renewal and new installation in that they can lower the life-cycle cost including future maintenance expenditure such as for sediment removal works. However, their installation needs, as indispensable preconditions, real time watching and monitoring of the facilities and rigorous road networks for maintenance access, such as removal works, even during and after major sediment washouts. Administrators are to make a new form of engagement in worksites. Legal and administrative liability would make a transition from that of risk management to that of risk itself which is manmade in nature and subject to operational and managerial mistakes. The transition would put sabo work into a new stage. Renewal and new installation are planned at several sites where above-mentioned preconditions of watching and monitoring as well as transportation access are met in upper Tenryu reach, together with elaborative drafting of standards for facility operations. The planned sites and a typical form of sabo dams with lateral closure screen bars are shown in Figure 10 and in Figure 11 (Ninose sabo dam) respectively. Also shown in Figure 12 is a prospective form presently in design stage to augment temporal fine particle trapping function between main check dam and supplemental sub check dam, with a view of both major sediment discharge and necessary sediment supply to downstream (renovated form for Koseto sabo dam under planning).

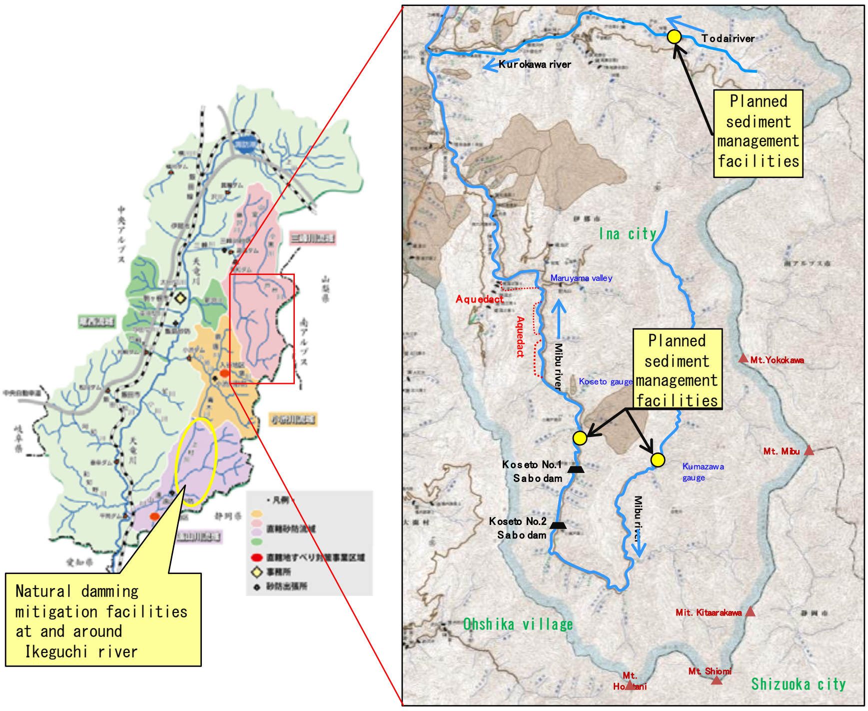


**Figure 10 Locations of planned sabo dams with lateral closure screen**

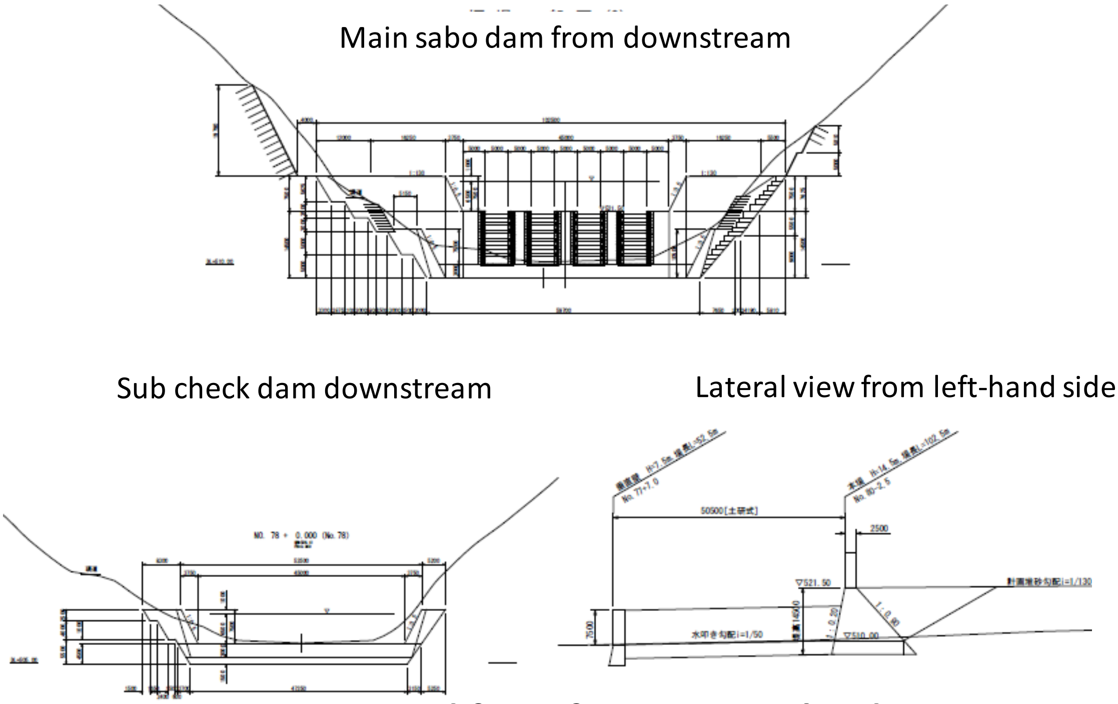


**Figure 11 Designed form for Ninose sabo dam**

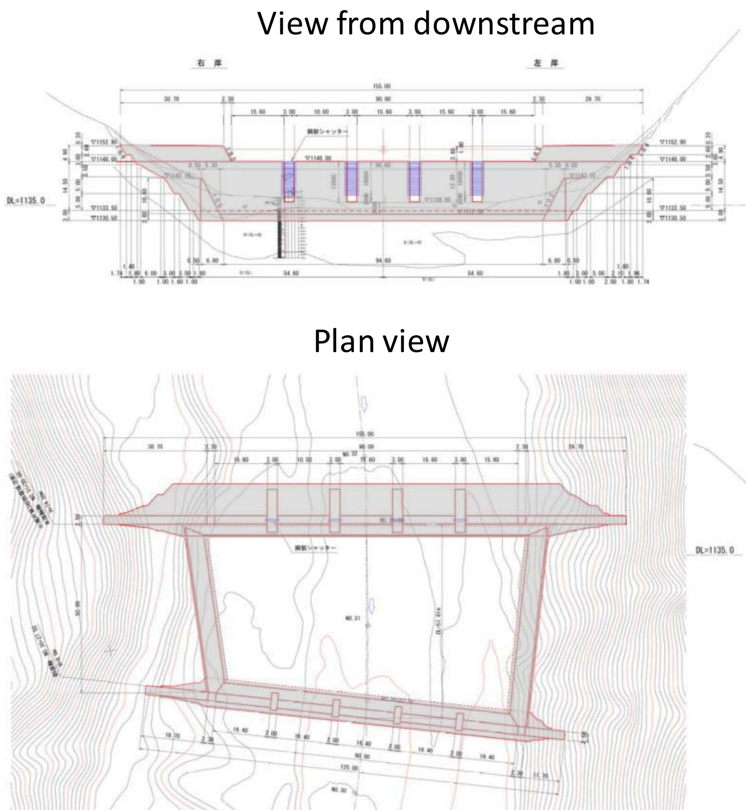


**Figure 12 Designed renovated form of Koseto No.3 sabo dam**

Sabo dams perform well as sabo facilities for their low environmental disruption and high economic efficiency, since they make use of sediment washout itself for river bed and bank protection in mountain streams and of natural floods for the restoration and conservation of sand trapping function. On the other hand, mass and slope stabilization of deep-seated failures and landslides in their places, in view of defending properties and sustaining facility functions, is demanded more often, as properties and facilities grow in their size and concentration. These are housing properties densely developed around urban areas and critical transportation networks, for example. Engineering practice and cost calculation of direct work expenses have regarded it the most efficient *in situ* works to simply put sabo facilities right downstream of slopes under consideration in order to raise river beds for loading at their foot. Nature of objects for mitigation may, however, make it impossible to put loading embankment in the front side. Solely suppression works are admissible instead of prevention works in that case. Fast actions are demanded at the same time for executions as the importance of objects stipulates. Well points and deep well pumping/drainage works, a kind of suppressive works, have been known for their fastness. Both methods are not readily put in place to mountainous and hillside slopes for their limited applicable depths and lack of field-proven cases. Active drainage methods to deep-seated failures and landslides have to be examined thoroughly for robust and proved functions of facilities, upon the better knowledge of their practical limits and properties. Applicability of combined pumps, an improved active drainage method, was studied at the site of Konota landslide area in Minami Shinano, Iida city. The combined pumps have the following characteristics:

a. A pushup pump is inserted down at the bottom of vertical drainage pipe in the ground as the same as deep well method.

b. An air-vacuum pump for air exclusion from the pipes is jointly placed on the ground surface, which enhances drawing suction from surrounding ground mass by lowering the level of atmospherically-balanced surface within the pipes.

c. Persistent vacuum drawing effect is kept through covering the outer sheath of casing up to a certain depth by engineered air-tight material with water permeability.

d. Simultaneous actions of two combined pumps strengthen drawing suction further by active waving and swinging propagation of suctioning negative pressure into the surrounding areas.

Konota landslide area is in need of the installation of combined pumps, also with a view to examine and to improve water percolation rates as its works are protecting San-En-Nanshin auto route, a branch of Tohyama river of class A Tenryu river, and populated districts. The auto route connects Shizuoka and Aichi prefectures to Nanshin area of Nagano prefecture. An overview of Konota landslide area and that of examined combination pumps with its installation layout are shown in Figure 13 and in Figure 14. The economic superiority of combined pumps was demonstrated in field as they perform with one-third to one-fifth of the corresponding cost of vertical gravitational drainage wells with lateral hydraugers, in terms of net present value estimated under the assumption of 40-day operation a year, 40 years of operation, 4% annual discount rate. The active drainage method can minimize adversarial impacts on existing water uses as it is operated once the level of groundwater is monitored and forecast to rise. Elaboration of standards for facility operation and prior clarification of legal and administrative liability are the prerequisites for its field installation as the case of sabo dams with lateral closure screen.

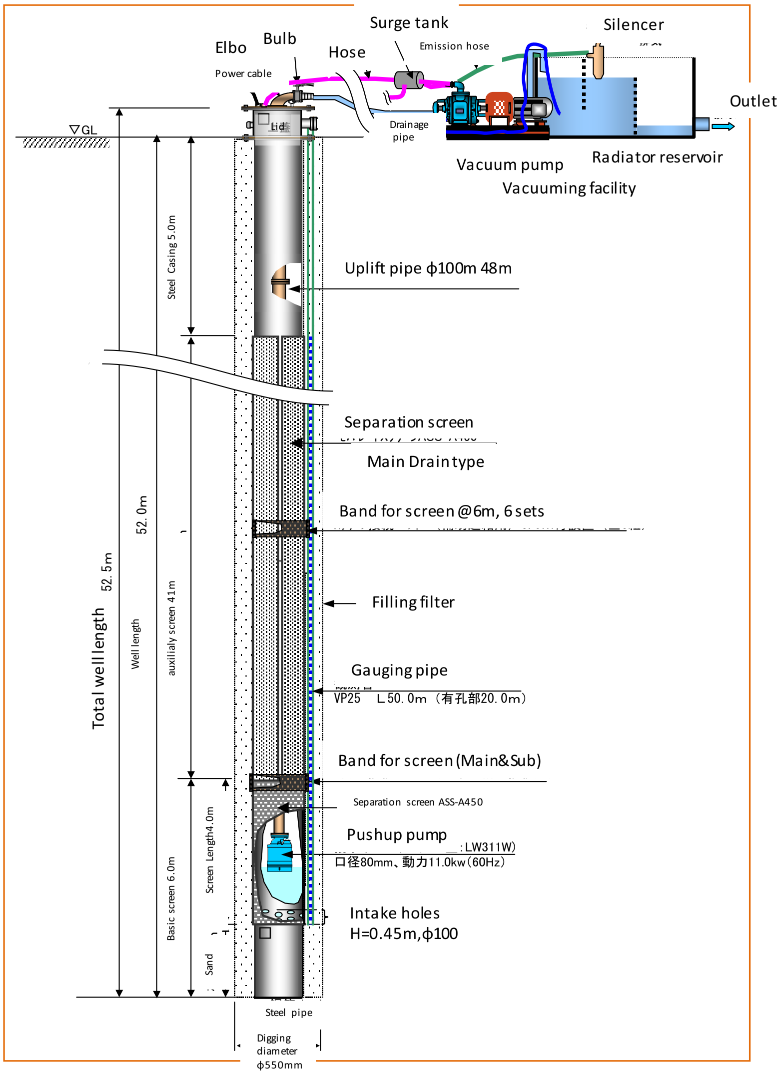


**Figure 13 Installation overview of combined pumps**

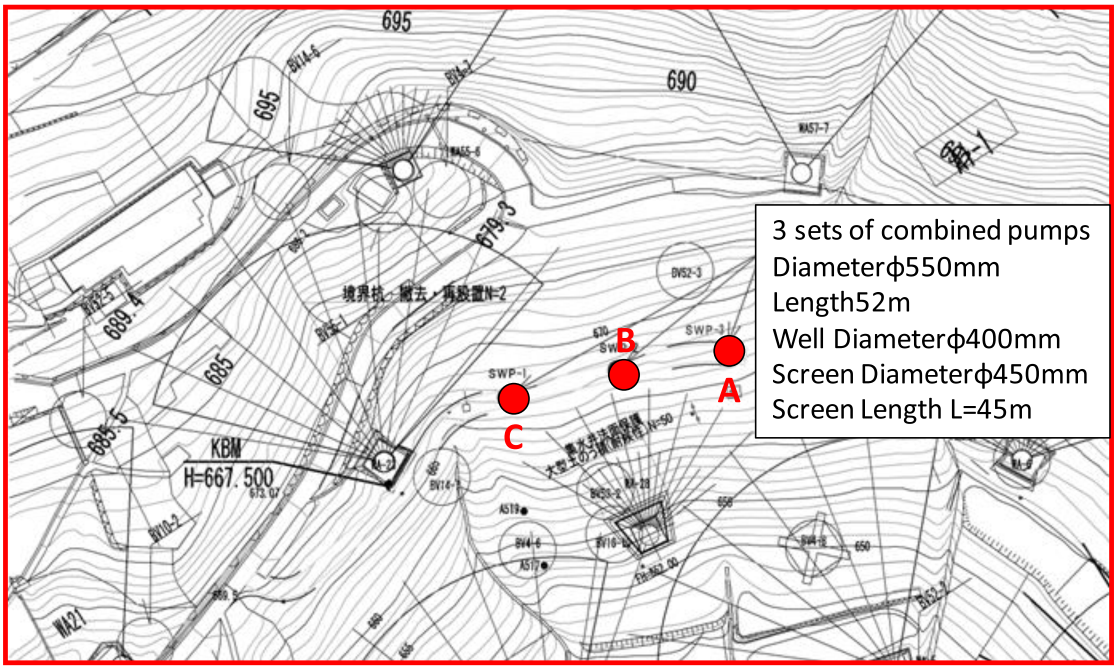


**Figure 14　Installation overview of combined pumps (3 sets)**

IV. Indirect actions on phenomena

It would be unwise for sabo work to depend only upon direct self-execution methods which always have to be accompanied with budgetary expenditures, as stagnantly low-level of public works budget seems to be rather normal in the prolonged economic standstill. Therefore, indirect actions to accomplish the goals of sabo work through information dissemination and education are studied. Indirect actions are different from direct ones in the following ways:

a. The actions and influences are more sustainable as the budgetary resources are less constrained.

b. Their effects and influences can be extended beyond planned areas whereas, in contrast, direct actions are neither expected nor allowed to have effects outside of work sites in a narrow sense.

c. They are neither fast nor assured fully in their effects.

d. Cooperation on the part of related parties and local residents is a necessary condition for their execution.

Mass and sediment can exert detrimental impacts on the society in each process of washout, fluid, flow-down, local sedimentation, scour, and erosion. Direct actions are suitably taken for frequent, large-scale, and prevalent ones. Conversely, indirect actions are taken for rare, or small and non-prevalent ones. It is because the latter case has a clearly definable group of interested parties and residents, where identifiable latent beneficiaries have no reason not to react at their own costs. Sediment-related disaster prevention law was legislated for the purpose of inducing safe land use by pre-designating hazardous areas of mass wasting and landslides upon Hiroshima disaster of June, 1999. The law has stipulated Special hazard zones, for the field designation of which prefectures are advised to make Basic surveys in a prescribed way. The law was largely amended for the third time after another latest Hiroshima disaster of August, 2014, occurred once again with 15-year elapse from the previous one. The amendment stipulates public release of the Basic survey results without consents from related municipalities, which had been misconstrued as a necessary condition. However, it is observed that the enhancement of warning and evacuation is overly stressed in each stage of legislation and enforcement despite the fact they are not the essential main objective. The followings are considered to be reasons:

a. Informed agreement of land and property owners through explanation in public town meetings, though not legally-binding, is misunderstood to be a de facto requirement in a process of Basic survey and formal zonal registration.

b. Current owners of land and property strongly oppose to disclosure that can counteract to their interest, to their detriment, as private ownership is regarded indisputably inalienable by general public, even if the disclosure uncovers not more than inherent enclosed risks.

c. Designation of zones is susceptible to local bargaining aiming to displace and/or to transform as there is a room for engineering discretion in the method of Basic survey.

d. Real estate trades remain almost beyond influence because of their low liquidity and transaction infrequency.

e. Engineering methods for recognition of structural proof against mass wasting, homogeneous to that of seismic proof, are immature. Building reinforcement efforts within the hazard zones are not assisted well. For example, loan and subsidy are not rendered fully available.

f. Survey and office expenses for legal Basic survey are not sufficient in comparison with the grant accorded in line with opaque cost estimation in normal regional delivery tax.

g. Mere land information disclosure if seen in and of itself, it tends to be mal-aligned with general disinterest allocation issues as administrative execution capabilities are eroded on the part of local municipalities.

h. The survey is entangled with disorder and retarding ground-level survey for cadastral maps to recognize title registration, also together with vacant house problems including unknown ownership in depopulated regions.

Policy and administrative efforts have been made to mitigate mass wasting hazards through dissemination of Landslide alerts and ascertained transmission through local municipalities. Nominal achievement rates of the Survey and registration are approaching 100% as well, whose common denominators, perilous areas, had been set primarily on paper from mid-1980s to at the latest 2000 for would-be facility installation by the Ministry of construction, the predecessor of present MLIT. The MLIT perilous areas excludes notably mass wasting hazard areas in forest and at its margin under the jurisdiction of National Forestry Agency. Further improvement is a pressing concern for better comprehensiveness of areas subject to the survey, locational precision and form appropriateness of legally registered zones as more than half of actual damages are sustained outside of the pre-registered areas. Principal initial objectives of the legislation are to be met through further down-to-earth efforts.

Cost efficient mitigation is critical to contain washout hazards, such as debris flows, and backyard minor landslides which have given rise to disproportionate property damages, as they are the main part of damages induced by mass wasting. They are relatively small in their size but outnumber other kinds under a broader perspective. They are not suitable for major objects of public works, including sabo dam installation for their low prevalence and intense locality. Their size rules out direct administration by national sabo work. However, emergency survey and works are requested without exception in time of actual disasters as they are prone to cause human casualties. Therefore, information dissemination to property owners and potential developers at normal time, even if the properties are not under direct jurisdiction, is justifiable to concentrate limited human and organizational resources in monitoring and management of sabo facilities that have impacts on larger areas. Land and property owners themselves are willing to know the negative risk information of mass wasting hazards entailing to their real estate properties. On the contrary, they are reluctant, if put mildly, to be known by others. Potential flow depth and velocity of mass and sediment wasting are estimated only stochastically as a range value. The numerical non-unique nature inevitably invokes disputes between those on the slack but safe side, and on the restrictive but risky side, at the time lines are strictly drawn in a legally binding way. Ranged values estimated and offered by administrators are to be dealt as a reference, rather than binding, in a sense. On the other hand, past records from complied survey results of damaged properties enable us to estimate the extent of damages. The damages are varied primarily by the set value of flow depth and velocity of incoming mass and sediment with a certain degree of reliability. Again with a range, but the latter estimation has less room for engineering discretion, and thus for argument, than the span of areal designation. Numerical values are up to engineering judgement and subjective by nature. It would be needed to enable land and property owners to make an informed selection of values for better self-help, so that they themselves are sure of imminent risks and of necessary level of housing reinforcement. A prototypical interactive tool is developed in order to make a simple house damage risk estimation induced by mass wasting and floods for each category of buildings in upper Tenryu reach. It makes a full use of estimation output of mass and sediment floods, as well as past housing damage records documented in flood control economic manuals. Prototype version is made in a form of user-friendly web application accessible from mobile devices as smartphones whose screen image is in Figure 15. Accuracy of estimation is yet to be improved as it is based on simple methodical algorithm. Another module for damage reduction by building reinforcement is still on a developmental stage, not suitable for installation. Natural hazards have a variety from earthquakes to standing inundation. The web application would be use to provide a primitive platform for further collaboration with such professionals of building reinforcement methods as local builders and inspectors of municipalities.

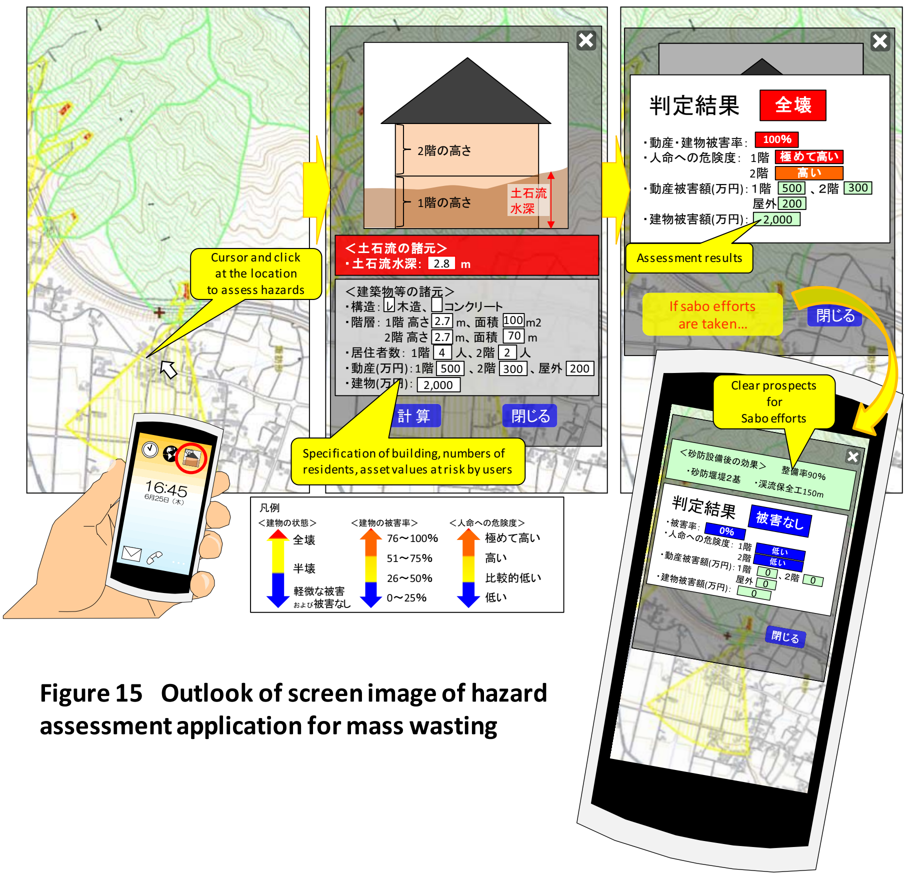


**Figure 15 Outlook of screen image of hazard assessment application for mass wasting**

Success rate of warning and evacuation from mass wasting is quite low. Therefore, success cases are to be taken as an exception rather than a rule for the following natures of mass wasting hazards:

a. Whether they occur or not is up to a judgment before the events.

b Time, location, and magnitude of occurrence are not foreseeable.

c. Actual field situation is not knowable even during or immediately after the events.

d. Information necessary for judgment is seldom attainable in power outage caused frequently by outburst of heavy rain.

e. Excessive inflow of diverse information, with variety of quality, leaves little room to bear additional information processing loads neither on the part of local residents nor on municipalities, in time of major catastrophes.

f. People are inadvertently influenced by cognitive bias of normalcy as most are experienced for the first time in their life due to the infrequency.

g. (Dis)advantages with evacuation and with inaction, staying in the present location, are determined by on-going changing conditions, even if evacuation is well pre-planned.

h. Evacuation is hardly practical as it is to be carried out in heavy rain at night.

i. Evacuees face physical challenges in evacuating themselves because there are many seniors among them.

j. Evacuation is not practical as evacuation routes and emergency shelters are often washed away themselves in times of major catastrophes.

The binding conditions mentioned above are to be taken into full consideration even if some exceptional fortune makes evacuation possible. Thus, proper land use and housing reinforcement are to be put at the center of mitigation effort to reduce human casualties from mass wasting disasters. The higher the cognition at ground levels, the more effective warning and evacuation can be, to which instructive drill and training of preplanned evacuation are conductive. Local municipalities have already shouldered a significant part of the efforts. On the other hand, more efforts are needed with respect to election of information items necessary for judgement and to reduction of overlapping items. Nobody has an unlimited capacity to process information in time of disasters. Useless ones are to be lined out to make them more succinct and concise. Suitable items and materials are to be disseminated on time, to the extent they are closer and more tangible to mass wasting phenomena. Weather information such as amounts of precipitation, be it forecast or actually observed, has remained at the center of information related to mass wasting phenomena. Precipitation has surely played a critical part with respect to the outlook of impending mass wasting hazards, as it puts a last straw on destabilized slopes. It has nonetheless its own limitation as a kind of potential, as opposed to actual, information. Nagano prefecture is largely mountains with its average altitude over 1,100 meters (700 feet) above sea level. Orographic effects on precipitation are obstacles for weather as well as hydrological observation. It is likely, for example, that in the debris flow disaster in Nagiso town, Kiso county, July 2014, the amount at the upstream source areas reached as high as twice of that monitored at the town office. Such kind of downpour is not adequately watched by weather radars, even with prospective improvement in the future because of its principle. It is imperative to make more effort to acquire actual information reflecting phenomena, even if it partially includes estimation, in addition to potential information used to this day. Detection information of major mass movement and wasting together with flood and sediment discharge in mountain streams can be counted as among items underdeveloped so far, to name a few. Once the contents and items are scrutinized fully, they are to be passed on to local public directly. Amplified sirens are supposed to be used right next to national sabo project sites as a standard practice. However, it is widely known that emergency calls do not penetrate heavy rain and thunderstorm even when provided through wireless speakers. Furthermore, town officials in charge of emergency situation are too preoccupied to spend what little time they have for information dissemination and ascertaining thereof.

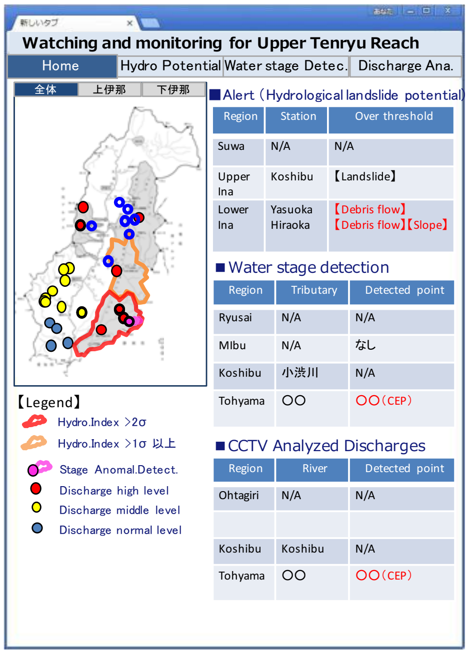


**Figure16 A proposed view for public dissemination**

Local residents are entitled to have a sure access to needed information even during power outage. It is supposed to be readily accessible from handy devices and understandable to a novice with little special expertise. Public dissemination through a screen format is under development in upper Tenryu reach as shown in Figure 16. Contents are to be revised so as to cover every conductive items out of those explained in Comprehension of phenomena. Detection information obtained through the NAtional CAtastrophic landslide Data Acquisition System (NACADAS) is yet to be included as the dissemination is subject to a proper combination with other monitoring outputs.

1961: Ohnishi  Yama Major Failure of Saburoku Disasters
( Ohshika Village)

1982: Major mass wasting  in Mibu river
( Hase, Ina city)

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